MONTHLY NOTICES

OF THE

ROYAL ASTRONOMICAL SOCIETY

Vol. 110 No. 2 1950

ANNUAL REPORT OF THE COUNCIL

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NOTICE TO AUTHORS

1. *Communications.*—Papers must be communicated to the Society by a Fellow. They should be accompanied by a summary at the *beginning* of the paper conveying briefly the content of the paper, and drawing attention to important new information and to the main conclusions. The summary should be intelligible in itself, without reference to the paper, to a reader with some knowledge of the subject; it should not normally exceed 200 words in length. Authors are requested to submit MSS. in duplicate. These should be typed, using double spacing and leaving a margin at one side. Corrections to the MSS. should be made in the text and not in the margin. By Council decision, MSS. of accepted papers are retained by the Society for one year after publication; unless their return is then requested by the author, they are destroyed.

2. *Presentation.*—Authors are allowed considerable latitude, but they are requested to follow the general style and arrangement of *Monthly Notices*. References to literature should be given in the standard form, including a date, for printing either as footnotes or in a numbered list at the end of the paper. Each reference should give the name of the author cited, irrespectively of the occurrence of the name in the text (some latitude being permissible, however, in the case of an author referring to his own work).

3. *Notation.*—Authors should conform closely to the recommendations of Commission 3 of the International Astronomical Union (*Trans. I.A.U.*, Vol. VI, p. 345, 1938). Council has decided to adopt the I.A.U. 4-letter abbreviations for constellations where contraction is desirable (Vol. IV, p. 221, 1932).

4. *Diagrams.*—These should be drawn about twice the size required in print and prepared for direct photographic reproduction except for the lettering which should be inserted in pencil. Legends should be given in the manuscript indicating where in the text the figure should appear. Blocks are retained by the Society for 10 years; unless the author requires them before the end of this period they are then destroyed.

5. *Tables.*—These should be arranged so that they can be printed upright on the page.

6. *Proofs.*—Costs of alteration exceeding 5 per cent of composition must be borne by the author. Fellows are warned that such costs have risen sharply in recent years, and it is in their own and the Society's interests to seek the maximum conciseness and simplification of symbols and equations consistent with clarity.

7. *Revised Manuscripts.*—When papers are submitted in revised form it is especially requested that they be accompanied by the original MS.

Reading of Papers at Meetings

8. If a paper is to be read at a meeting it should be received by the Assistant Secretary not later than the previous Friday.

9. When submitting papers authors are requested to indicate whether they will be willing and able to read the paper at the next or some subsequent meeting, and approximately how long they would like to be allotted for speaking.

10. Postcards giving the programme of each meeting are issued some days before the meeting concerned. Fellows wishing to receive such cards whether for Ordinary Meetings or for the Geophysical Discussions or both should notify the Assistant Secretary.

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ANNIVERSARY MEETING OF 1950 FEBRUARY 10

Professor W. M. Smart, President, in the Chair

The election by the Council of the following Fellows was duly confirmed :—

William Edwin Leslie Clapham, 18 Rogers Avenue, East Brighton, Melbourne, Victoria (proposed by E. B. Walton);
Dennis Foster, 53 Brewerton Road, Oldham, Lancashire (proposed by I. F. H. Carr-Gregg);
Alister Ivan McClelland, 36 Leake Street, Peppermint Grove, Western Australia (proposed by H. S. Spigl);
Leo Randić, D.Sc., Zagreb University, Yugoslavia (proposed by W. M. Smart); and
Peter Alan Sweet, M.A., University Observatory, Glasgow (proposed by W. M. Smart).

Sixty-five presents were announced as having been received since the last meeting, including :—

H. P. Wilkins, 100-*inch Reproduction of the* 300-*inch Map of the Moon* (presented by the author);
M. G. J. Minnaert, *De Natuurkunde van het Vrije Veld, Part I* (presented by the author); and
M. G. J. Minnaert, *Dichters over Sterren, een bloemlezing en ingeleid door M. G. J. Minnaert* (presented by the compiler).

The Address on the award of the Gold Medal was delivered by the President (see p. 179), after which the Medal was handed to Dr C. S. Pigott, Scientific Attaché to the United States Embassy, for transmission to Professor Joel Stebbins, Ph.D., Sc.D., to whom it had been awarded for his development of physical methods in astronomical photometry and for the results obtained by the use of those methods.

ANNUAL GENERAL MEETING OF 1950 FEBRUARY 10

Professor W. M. Smart, President, in the Chair

The Minutes of the preceding Annual General Meeting were read, confirmed and signed.

The President having appointed the Scrutineers, the Society proceeded to the ballot for Officers and Council for the ensuing year.

The Secretary read extracts from the Narrative Report of the Council.

The Report of the Honorary Auditors was read (see p. 108).

The Treasurer gave a brief explanation of the accounts and a survey of the Society's financial position.

A vote of thanks to the Honorary Auditors of the Treasurer's accounts for 1949 was proposed and carried unanimously.

It was proposed and carried that the Report of the Council be received and adopted, and that it be printed and circulated in the usual manner, together with the Report of the Honorary Auditors and the President's Address.

The Treasurer, on behalf of the Council, moved the adoption of the amended Bye-law 23 below, which was put to the Meeting, and after some discussion, adopted unanimously :—

> 23. Any Fellow may at his entrance compound for his annual contributions, exclusive of his admission fee, by the payment of a composition fee of seventy guineas less one guinea for each year of age (on the first day of January in the year of entrance) in excess of thirty; or he may at any time afterwards (all sums then due having been paid) compound for his subsequent annual contributions, in which case the payment shall be the composition fee as calculated according to this Bye-law for the date of entrance, reduced by one and one-half guineas for each year of Fellowship with a minimum payment of ten guineas.

The Secretaries, on behalf of the Council, moved the following resolution, which was put to the Meeting, and carried unanimously :—

> That until the date of the next Annual General Meeting the Officers be empowered to remove from the library and to dispose of according to the Library Committee's instructions such of the Society's books as the Committee in the course of the reorganization of the library shall declare to be no longer needed.

The Scrutineers reported to the President the result of the ballot, and the names of the Officers and Council elected for the ensuing year were read to the Meeting. (The list of names is given on p. 196.)

The thanks of the Society were given to the retiring Vice-President (Professor W. H. McCrea), Geophysical Secretary (Mr B. C. Browne), and other retiring members of Council.

The thanks of the Meeting were given to the Scrutineers of the ballot.

The Meeting then adjourned.

REPORT OF THE COUNCIL TO THE HUNDRED AND THIRTIETH ANNUAL GENERAL MEETING OF THE SOCIETY

1. *General.*—With the prosecution of astronomical and geophysical research returning to normal after the extended interruption due to the war, pressure on space in the Society's publications continues to increase. Meanwhile there is no indication that the economic processes underlying the recent continual rises in the cost of printing will be checked in the foreseeable future. The deficits which have resulted from this combination of circumstances have accumulated and now reach serious proportions, and the Council has devoted much time to discussing means of avoiding further deficits in the future. Some of the lines of action which have been initiated are not yet at a stage where any detailed report can properly be made; of the others, the most important is the Council's appeal to Fellows to pay their annual contributions under seven-year covenants, a scheme of which the operation is described in some detail in Section 3 below.

Increasing pressure on space in the Society's publications is matched by similar pressure on its accommodation at Burlington House. The growing inadequacy of the Society's apartments to meet its commitments, notably to maintain as complete a library as possible of astronomical literature, has long been apparent. Long-term measures to combat this state of affairs are envisaged, and the Council is cooperating fully with the governing bodies of other learned societies, both within and outside the confines of Burlington House, in an endeavour to secure a dignified central home of adequate capacity for all the scientific societies. Even if these efforts are successful, however, they can hardly be expected to bear fruit within the next ten years. Meanwhile, as a short-term contribution to the problem, some reorganization reported below in Section 9 will ease matters for at most two years ; after that time some major additions must be made to the shelf space.

Two recent innovations in the Society's activities continue with marked success. First, the number of Junior Members is increasing at a rate which amply justifies the institution of this class of membership ; and already the first transfer from Junior Membership to Fellowship has taken place. Second, a highly successful and well-attended meeting of the Society was held at Manchester in the summer of 1949, and as the result of an invitation from the Royal Irish Academy another is projected for Dublin in 1950.

2. *Membership.*—The Council regrets to record the deaths of the following Fellows, all of which were reported in 1949:

*Charles Anthony	*William Duncan MacMillan
*George Alexander Sime Atkinson	*Edmund Sewall Manson
Arnold Buxton	Joseph H. Moore
*Philip Herbert Cowell	Herbert James Read
William Rhys Evans	John Rees
Mary Acworth Evershed	*John Henry Reynolds
Clyde Fisher	Thomas Henry Locke Roberts
William Thomson Hay	Charles Frederick Ortmann Smith
Malcolm Parker Miller McLean	*Julius F. Stone
	Cyril Young

*Life Fellow.

Obituary notices of some of these Fellows are printed on pp. 124–135. A detailed analysis of the membership of the Society is given in tabular form on p. 109.

3. *Finance.*—The Treasurer's annual accounts are presented in the customary form on pp. 110–115.

During the year the Society received a bequest from the late R. W. Wright of £25, which has been added to the General Fund.

The reduction in the deficit on the General Fund Revenue Account from £968 in 1948 to £113 in 1949 gives a more optimistic view of the present finances of the Society than is justified. The estimate made for the 1948 accounts of the costs of the publication of that year which had not been invoiced or printed by the end of the year proved to be too great by nearly £400. The true deficit for 1948 requires to be reduced and that for 1949 to be increased by this amount; the results for the two years are then not greatly different. The increase in the membership of the Society, which for the first time in the history of the Society exceeds 1000, is gratifying. The high costs of printing are the cause of much concern; the amount of printing in any one year will be the main factor in determining whether or not there is a deficit for that year.

It will be apparent that in spite of the recent increases both in annual contributions and in composition fees the Society's income is insufficient to meet its current expenditure, even if the Royal Society's grant of £850 from the Parliamentary Grant-in-Aid for Scientific Publications is regarded as normal income. Indeed, that the deficit this year is as small as it is must be attributed in part to the unexpected accession of a further grant of £150 from this source for library purposes. The present position is the direct result of three main factors: the increased cost of printing, services and salaries, the diminution of bequests, and the reduction in income from investments. He would be an optimist indeed who looked to the reversal of any of these trends in the near future. Meanwhile, the Government has greatly increased its financial support to the universities, has set up on generous lines a National Institute of Oceanography and has announced its intention of establishing an Isaac Newton Observatory: all actions deserving of the Society's enthusiastic support, but

all designed to increase the output of research, much of which the Society must expect to be asked to publish. The Council, which cannot contemplate even the present state of affairs with equanimity, views with some alarm the situation which may present itself in the next decade in the absence of a substantial increase in income. It is of the opinion that a further increase of annual dues at the present time would not lead to an increase of anything like the amount needed, though the Annual General Meeting in 1950 February will be asked to sanction an increase of approximately 50 per cent in composition fees, and a subsequent rise in annual contributions cannot be excluded. It has therefore given long and careful consideration to the present and probable future state of the Society's finances, and has initiated a course of action which it is hoped will put them on a more satisfactory basis.

No short-term results can however be expected from this action, nor indeed is it designed to achieve them. Meanwhile there is one way in which individual Fellows can at no cost to themselves make possible a very substantial increase in the Society's income from subscriptions. This lies in enabling the Treasurer to take as full advantage of the Society's status as a charitable organization in respect of this income as he already does in respect of income from investments. Where income tax has been deducted at source from this latter income, he can and, of course, does reclaim it from the Inland Revenue authorities on the ground that the Society is not liable to income tax. Now in many cases—indeed in most cases where the Fellow concerned is resident in the British Isles—annual contributions are paid to the Society out of income which has already been subjected to income tax, for few United Kingdom Fellows escape the incidence of this tax, if not at its full rate then at a rate which, though reduced, is still very high by pre-war standards. It is therefore logical that the Society should be able to claim back from the Inland Revenue such tax as has already been paid by the Fellows in respect of their annual contributions. For statutory reasons it is necessary, before such claims can be entertained, to show that the contributions are an inescapable call on the Fellows' resources for at least seven years. If, therefore, Fellows who are liable to British income tax will covenant to pay their annual contributions to the Society for periods of at least seven years, the value to the Society of their subscriptions can be raised through recovery of tax by a quantity which, at the current full rate of tax, amounts to no less than 82 per cent. If 400 such Fellows paid their annual contributions under seven-year covenants the deficits which have been so depressing a feature of these Annual Reports for the past few years could be wiped out as quickly as they have accumulated, and the Society could face with greater equanimity those future calls on its income that have been predicted above.

The paper work in which the scheme would involve a participating Fellow is negligible—all that is required is an initial contract of only a few lines, and then, once each year for seven years, a simple statement of the rate of liability to tax. Should a Fellow die within seven years of making the covenant, there is no further call on his estate. Thus with no immediate or future financial commitment beyond what is already involved in continued membership for seven years, Fellows can release from national revenue really substantial additions to the Society's funds. All who are liable to British income tax are earnestly urged to respond to the Treasurer's appeal recently circulated to them.

4. *Meetings.*—During 1949 the customary eight Ordinary Meetings were held in the Society's apartments at Burlington House ; they were attended by an average of 70 Fellows. The six Geophysical Discussions also held attracted an average of 39 Fellows and visitors. In addition to these, a special meeting took place on July 1 at Manchester with the cooperation of the University of Manchester and the Manchester Astronomical Society. Opportunity was taken on this occasion to visit the Jodrell Bank Experimental Station, where much of the pioneer work in radio astronomy is being conducted. Factual details of the meetings have appeared in *Monthly Notices*, **109**, pp. 387–8, but it is fitting for the Council to record here the Society's grateful thanks to those who made the visit so striking a success. Expressions of these thanks have already gone to Sir John Stopford, M.D., F.R.S., Vice-Chancellor of the University, for affording the Society the hospitality of academic Manchester in innumerable ways; to Professor P. M. S. Blackett, F.R.S., Director of the Physical Laboratories, for opening the laboratories to Fellows' inspection and for making available a comfortable meeting-room for the Ordinary Meeting and the Geophysical Discussion on the following day ; to Dr N. Herlofson for attending to countless matters of detail as a most efficient local secretary ; to Dr A. C. B. Lovell for organizing the Jodrell Bank visit so successfully; to Dr M. A. Ellison for delivering to a crowded audience on the evening before the meeting a public lecture entitled " Sun, Radio and the Stars " ; and to Mr J. C. Farrer, President of the Manchester Astronomical Society, for presiding on this latter occasion and for placing his local knowledge so freely at the disposal of visiting Fellows.

The Ordinary Meeting in October was devoted to the George Darwin Lecture, which was delivered by Professor Otto Struve, 1944 Gold Medallist, who took as his subject " Spectroscopic Binaries ". The address appears in *Monthly Notices*, **109**, pp. 487–506.

At the April and May meetings Dr R. G. Giovanelli, of the Australian National Standards Laboratory, presented papers; and in November the Society welcomed both Professor B. Strömgren, who gave an account of recent progress in astronomy in Denmark, and Dr D. S. Evans, who, in addition to reading a paper, described the work now in progress at the Radcliffe Observatory in Pretoria.

5. *Awards.*—The Council awarded the Gold Medal of the Society to Professor Sydney Chapman for his contributions to geophysics and solar physics, and particularly to the theory of geomagnetic phenomena. The presentation was made at the Anniversary Meeting in February by the President (Professor W. M. H. Greaves), who made a review of Professor Chapman's work the basis of his Presidential Address on that occasion (*Monthly Notices*, **109**, p. 258).

At the same meeting the President presented the Jackson-Gwilt Medal and Gift to Mr A. M. Newbegin for his observations of solar phenomena during the past 40 years.

6. *The Isaac Newton Observatory.*—Progress in the optical and mechanical design of the Isaac Newton Telescope is reported in the second Annual Report of the Board of Management, which appears as Section X of the Astronomer

Royal's Report to the Board of Visitors of the Royal Greenwich Observatory dated 1949 May 28.

The Council has appointed Professor W. M. Smart as the Society's representative on the Board of Management for the three years beginning on 1950 January 1. Professor Smart succeeds Dr J. A. Carroll, who has completed his term of office.

At the Ordinary Meeting of the Society in May the Astronomer Royal reported that during his recent visit to the United States the Trustees of the McGregor Fund had offered, for use in the Isaac Newton Telescope, a pierced 98-inch pyrex glass disk in their possession, together with its central plug and a 26½-inch disk for a secondary mirror. Fellows will share the Astronomer Royal's satisfaction at this most generous gift which, it is estimated, will bring completion of the instrument two or three years nearer than would otherwise have been possible. The disks have now arrived safely in Great Britain and are at present stored at Greenwich.

7. *Publications.*—During 1949 the Society published and distributed the following:

Monthly Notices, Vol. **108**, Nos. 5 and 6; Vol. **109**, Nos. 1, 2, 3 and 4.

Geophysical Supplement, Vol. **5**, Nos. 8 and 9.

Occasional Notes, No. 13.

At the end of the year *Monthly Notices*, Vol. **109**, No. 5 was in proof and copy for *Geophysical Supplement*, Vol. **6**, No. 1 and *Occasional Notes*, No. 14 was ready for setting up.

A small but steady demand from non-Fellows for *Occasional Notes* has led the Council to decide that all issues of this publication shall be put on sale to the public.

8. "*The Observatory*".—The arrangement with the Editors of "*The Observatory*" by which this magazine is distributed to Fellows in return for a block payment by the Society continues, it is believed, to operate to the advantage of both sides. When it was last revised in 1945, the Editors undertook to supply approximately 750 copies of each issue, a number then sufficient to afford one to each active Fellow. Since then the names of many Fellows have been transferred to the distribution list from the Suspense Account list, and it is mainly for this reason that the number being supplied has increased to more than 1000. The Council has therefore agreed to the Editors' request to increase the block payment from £125 to £160 annually.

9. *The Library.*—The Library has been used rather more than in 1948. The number of visitors for consultation reached about 93 a month, and 490 books were borrowed by 126 different borrowers.

On p. 121 appears a list of those institutions and persons who have presented gifts to the library during the year 1949 otherwise than by exchange.

Part of the Parliamentary Grant-in-Aid for Scientific Publications was this year set aside for the purpose of the scientific libraries, and the Council has expressed to the Royal Society the Society's appreciation of a grant of £150 from this source.

The services of Miss Wadsworth as part-time Librarian have been retained during the year. In order to utilize to the full her unique knowledge of the library in the onerous task of reorganization, some of the more routine work involved in the preparation of the new index card has been performed by Mrs F. L. Walmsley, who was engaged as a temporary clerical worker during the summer months.

Much of the preliminary work of reorganization has now been finished, and at the end of 1949 the Library Committee was in a position to invite the cooperation of a panel of some two dozen experts to advise the Librarian on the preparation of the new classified catalogue. Their reports on the various subject sections of the library will include amended classifications and cross-references, recommendations to discard unsuitable works and duplicates, and proposals to make additions.

The physical reorganization is a task for the future, but when it does take place it will inevitably add to the existing heavy demand on shelf space for normal accessions. In order to relieve this pressure the Council has authorized the erection along the north wall of the Council room of shelving to store some of the Society's more valuable books, and also the clearance of a room on the top floor hitherto used for storage of back publications but now destined to house additional shelving for general library expansion. This clearance has itself made imperative a partial emptying of the stock-room in the basement to make room for normal accumulation of back numbers as time goes on. In order to accomplish this, the Council has decided to reduce the Society's stocks of certain of its publications by offering the surplus, for no more than the cost of packing and carriage, to Fellows and Observatories. This offer applies at present only to *Monthly Notices* published prior to 1930. A considerable response has resulted, and distribution will start after 1950 June.

It happens not infrequently that a Fellow requires for his personal use a paper appearing in a periodical of which the astronomical content is not normally sufficient to justify the Society in subscribing. By arrangement with the Science Museum it is now possible in such a case for the Fellow to obtain at nominal cost a photocopy of the article, so long as the Science Museum Library takes the periodical and the publishers' consent has been obtained. In reciprocation, non-Fellows will be able to obtain photocopies of such of the Society's publications as are out of print.

10. *The Society's premises.*—The library and rooms were closed for cleaning from July 18 to August 2 inclusive. Letters and postal applications for the loan of books were however attended to as usual during this period. This arrangement proved so advantageous administratively whilst imposing so little inconvenience on Fellows, that it is intended to close the apartments for a fortnight each summer. The Library Regulations will be altered so that the date for the annual return of all books coincides with the date of closing the library for cleaning.

11. *Astronomical photographs.*—A list supplementary to that published in *M.N.*, **100**, p. 230, appears on p. 123. Stocks of photographs depleted or even exhausted during the war can be replenished only slowly, but if an application

is made for a particular photograph of which no copy exists, reproduction from the master negative is given priority, and orders can be executed without serious delay.

With the completion of the 200-inch Hale telescope and of the 74-inch Radcliffe reflector, the Society may expect numerous additions to its collection.

12. *Guest Societies.*—The British Astronomical Association and the London Mathematical Society held their customary number of meetings in the Society's rooms. Accommodation was also afforded to two Sectional Committees of the British Association, to certain Committees of the Board of Management of the Isaac Newton Observatory and to the Research Committee of the Norman Lockyer Observatory.

13. *Representation of the Society.*—The Council has made the usual provision for the representation of the Society on such outside bodies as require it. A representative has been appointed on the Governing Body of the newly formed National Institute of Oceanography, and a number of Fellows have been nominated to serve on a panel concerned with the presentation of astronomy in the Festival of Britain 1951. The Society's meeting in Manchester has stimulated the formation of an informal consultative committee on Radio Astronomy on which, at the President's invitation, a number of Fellows have agreed to serve, together with several radio physicists.

The Society was represented by Dr W. H. Steavenson (Vice-President) and Dr A. Hunter (Secretary) at the memorial service to Mr W. T. Hay, by Professor H. H. Plaskett (past President) at the funeral of Mr J. H. Reynolds, and by Sir Harold Spencer Jones (Treasurer) at the memorial service to Dr J. H. Moore.

REPORT OF THE AUDITORS FOR THE YEAR 1949

We have examined the accounts of the Society and approve the various items of expenditure. However, it is disturbing to find that despite increased income from subscriptions there is again an adverse balance of expenditure over revenue, though much smaller than of recent years. Since the decrease is largely due to smaller printing costs, it appears unlikely to be maintained in the future. It is therefore highly desirable that Fellows should take advantage of the scheme for paying subscriptions by seven years' covenant, as a substantial response would add a considerable amount to the revenue.

We have checked the official list of Fellows against subscriptions received. We note with satisfaction a rise both in the number of active Fellows and in the number of Junior Members. Indeed, it gives us great pleasure to be able to report that for the first time in the history of the Society the total membership is over one thousand.

We have examined the premises of the Society. A beginning has been made on the execution of a plan for the overhauling and re-arrangement of the Library and the compilation of a classified catalogue, which is very welcome. Consideration should also be given to the question of interior decoration.

Finally, we gratefully acknowledge the help and the cooperation given us by the Assistant Secretary in providing the information that we required.

R. W. B. PEARSE.
J. C. P. MILLER.

PROGRESS AND PRESENT STATE OF THE SOCIETY

	Patron	Institutional Members	Fellows: Compounders	Fellows: Annual Contributors	Fellows: Non-active Fellows	Junior Members	Associates	Total
1949 January 1	1	5	215	678	13	11	49	972
Since elected	...	+1	+ 2	+66	...	+19	+ 2	...
Elected 1948, declared null and void	...	...	...	− 1	...	...	...	...
Elected 1949, declared null and void	...	...	...	− 1	...	...	...	...
Deceased 1949	...	...	− 6	− 9	...	...	...	...
Deceased prior to 1949, death not notified	...	...	− 1	...	...	...	...	...
Resigned 1949	...	...	...	−13	...	...	...	...
Since compounded	...	...	+ 4	− 4	...	...	...	...
Transferred 1949 from "War Conditions" to Active	...	...	...	+ 3	− 3	...	...	...
1950 January 1	1	6	214	719	10	30	51	1031

(N.B.—Ten Associates are also Fellows, and are therefore counted twice in the above table.)

Cash

RECEIVED		£ s. d.	£ s. d.	£ s. d.
Balances, 1949 January 1 :—				
In hand of Assistant Secretary, on Petty Cash Account			6 11 1	
At Westminster Bank, on Current Account as per Pass Book		392 1 7		
Less Cheques not presented		157 0 0		
		235 1 7		
Add Foreign draft not credited till 1949		3 7 4		
			238 8 11	
At Westminster Bank, on "B" Account :—				
A. S. Williams Bequest			52 10 0	
At Westminster Bank, on "C" Account :—				
Trust Funds, as per Pass Book (including Sales of Duplicate Books Fund, £4 1s. 2d.)		367 11 10		
Less Cheques not presented		4 2 0		
			363 9 10	
At Post Office Savings Bank :—				
General Fund		2,766 5 2		
"C" Account		723 0 10		
Staff Pension Fund		488 2 1		
			3,977 8 1	
At London Savings Bank :—				
Ordinary Department (including £250 A. S. Williams Bequest) ...		1,214 10 0		
Special Investment Department		614 4 3		
			1,828 14 3	
				6,467 2 2
Legacy from R. W. Wright, deceased				25 0 0
Parliamentary Grant-in-Aid for Scientific Publications, received through the Royal Society for 1949				850 0 0
Royal Society Grant for Library Expenses				150 0 0
Eddington Memorial Fund : Subscriptions received				285 18 4
Dividends on Investments			704 8 1	
Interest on Savings Banks Deposits			129 4 2	
Income Tax refunded : 1948 April to December...		125 4 9		
1949 January to April		102 1 5		
			227 6 2	
Sales of Publications :—				
Monthly Notices, 1949		486 18 9		
" " 1948		138 4 5		
" " 1950 in advance		59 16 0		
Geophysical Supplement		170 5 4		
Memoirs, Occasional Notes and miscellaneous		195 3 3		
			1,050 7 9	
Reprints :—				
For 1949			64 7 3	
Sale of Photographs and Hire of Slides, 1949			43 6 5	
Hire of Films			35 13 7	
Miscellaneous Receipts :—				
London Mathematical Society		30 0 0		
Assistant Secretary and Librarian, Contributions to Pension Scheme ...		65 8 1		
Postages repaid : 1948	£7 15 0			
1949	45 12 8			
Postages, 1950, paid in advance	4 7 6			
		57 15 2		
British Astronomical Association, 1948 July to 1949 October		150 0 0		
Contributions paid before election		10 5 0		
Contributions overpaid, and repayable		1 18 0		
Donation : W. M. H. Greaves		1 0 0		
Donation : Sundry		4 9		
Annual Donation under Covenant		27 10 0		
Refund of freight, etc. on Refractor sent to South Africa		42 19 1		
Sale of packing cases		1 12 0		
Credit note on Potter Fund, 1948, refunded		1 14 0		
			390 6 1	
				2,644 19 6
Received on Account of Contributions :—				
548 Annual Contributions, 1949	£1,726 4 0			
2 Partial Contributions, 1949, partly paid in 1948 ...	4 3 0			
17 Partial Contributions, 1949	27 6 0			
		1,757 13 0		
4 Institutional Membership Fees		12 12 0		
29 Junior Members' Annual Contributions		30 9 0		
57 Admission Fees, 1949	£119 14 0			
31 First Contributions at £3 3s.	97 13 0			
25 First Contributions at £1 1s.	26 5 0			
		243 12 0		
			2,044 6 0	
Arrears paid off :—				
3 Fellow's Annual Contributions, 1947	£6 6 0			
54 Fellow's Annual Contributions, 1948	170 2 0			
24 Partial Contributions, 1948	27 11 0			
8 Admission Fees, 1948	16 16 0			
8 First Contributions, 1948	8 8 0			
		229 3 0		
Contributions in Advance, received 1949 :—				
37 Annual Contributions for 1950	£116 11 0			
10 Partial Annual Contributions for 1950	17 7 0			
1 Partial Annual Contribution for 1951	1 17 0			
4 Junior Members' Fees, 1950	4 4 0			
		139 19 0		
Compositions :—				
1 Initial	£47 5 0			
1 Initial (reduced)...	45 13 6			
4 Reduced	107 2 0			
	200 0 6			
Less refund of overpayment in previous year ...	12 6			
		199 8 0		
			568 10 0	
				2,612 16 0
"C" Account :—				
Dividends on Investments			215 19 6	
Income Tax refunded			19 10 8	
Interest on Post Office Savings Bank Account			18 0 0	
Sales of Duplicate Books			30 10 0	
				284 0 2
Cash transferred from Westminster Bank, Current Account to London Savings Bank, Ordinary Department				500 0 0
				£13,819 16 2

Account

PAID		£ s. d.	£ s. d.	£ s. d.
Office Staff, including Librarian :—				
Salaries		943 17 9		
Income Tax on Salaries...		131 4 0		
National Insurance		29 9 7		
Assistant Secretary and Librarian : Pension Premiums (Society's Contributions £66 5*s.* 0*d.*; Staff Contributions £68 15*s.* 0*d.*)		135 0 0		
			1,239 11 4	
Porter and Wife : Wages and Cleaning		283 6 0		
National Insurance		19 5 8		
			302 11 8	
Charwoman : Wages...			32 4 0	
				1,574 7 0
Insurance			15 3 0	
Telephone			36 8 1	
				51 11 1
Printing, etc. :—				
Monthly Notices (Vol. **108**, Nos. 1, 2 and 3, on account)			846 16 10	
Reprints			53 3 2	
R.A.S. Prospectus			3 5 0	
Photo-engraving...			240 18 4	
				1,144 3 4
Postages and Packing :—				
Office postages				88 15 7
Stationery and Office Expenses			90 19 9	
Heating and Lighting			183 8 2	
Accountants' Fees			47 5 0	
Subscription to National Central Library			1 1 0	
Subscription to A.S.L.I.B.			3 3 0	
I.A.U. Telegrams			10 10 10	
Authorized Travelling Expenses			23 6 0	
Repairs, Fittings and Fixtures			92 15 4	
House Expenses and Laundry (less contribution from B.A.A. £5)			92 16 1	
Expenses of R.A.S. Meetings and Committees			54 5 8	
Bank Charges and Cheque Books			2 5 5	
Library Expenses (including shelving, etc. £57 4*s.* 0*d.*)			84 2 10	
Gold Medal			18 19 4	
Miscellaneous Expenditure			27 6 11	
Net deficit on Contributions			1 8 3	
				733 13 7
Expenditure charged to Reserve Accounts :—				
Repairs			230 5 4	
Reproduction of Slides and Prints			16 7 0	
Binding Periodicals			71 7 6	
Purchase of Books from Potter Fund			11 15 6	
				329 15 4
Science Library Photo-copying Service Deposit £5 (less £1 19*s.* 0*d.* recoveries)				3 1 0
Binding Periodicals			81 15 4	
Less Provided out of Reserve (*see above*)			71 7 6	
				10 7 10
Reproduction of Slides and Prints			112 2 6	
Less Provided out of Reserve (*see above*)			16 7 0	
				95 15 6
Block Subscription to *The Observatory*				142 10 0
Miscellaneous Expenditure :—				
Expenditure on Films			18 13 3	
Manchester Meeting Expenses			14 10 7	
				33 3 10
Expenditure on Trust Accounts :—				
Turnor and Horrocks Fund (Library)...			19 3 0	
Harry Watson Fund (Library)...			144 15 1	
George Darwin Lectureship Fund			50 0 0	
Hannah Jackson (*née* Gwilt) Fund			25 0 0	
				238 18 1
Cash transferred to London Savings Bank, Ordinary Department, from Westminster Bank, Current Account				500 0 0
Balances, 1949 December 31 :—				
In hand of Assistant Secretary, on Petty Cash Account			14 13 0	
At Westminster Bank on Current Account, as per Pass Book		2,051 16 7		
Less Cheques not presented		97 5 11		
		1,954 10 8		
Add Foreign draft not credited till 1950		8 1 11		
			1,962 12 7	
At Westminster Bank, on " B " Account (A. S. Williams Bequest) ...			52 10 0	
At Westminster Bank, on " C " Account :—				
Trust Funds, as per Pass Book (includes Sales of Duplicate Books Fund £34 11*s.* 2*d.*)		348 19 11		
Add Due from General Account		41 12 0		
			390 11 11	
At Post Office Savings Bank :—				
General Fund		2,835 9 8		
" C " Account		741 0 10		
Staff Pension Fund at 1948 December 31	£488 2 1			
Add Interest, 1949	12 4 0			
		500 6 1		
			4,076 16 7	
At London Savings Bank :—				
Ordinary Department (including £250 A. S. Williams Bequest) ...		1,746 18 8		
Special Investment Department		629 11 3		
			2,376 9 11	
				8,873 14 0
				£13,819 16 2

Dr. *General Fund Revenue Account*

	£ s. d.	£ s. d.
To Salaries and Wages, including Pension Premiums and National Insurance		1,511 18 1
„ Insurance and Telephone (after adjusting Reserves)		51 11 1
„ Printing, etc. (after adjusting Reserves)	2,904 6 3	
Less Amount received from the Parliamentary Grant-in-Aid for Scientific Publications through the Royal Society for 1949	850 0 0	
		2,054 6 3
„ Posting and Packing (after adjusting Reserves)		237 12 9
„ *General Expenses (after adjusting Reserves)* :—		
Stationery and Office Expenses	92 7 9	
Lighting and Heating	170 17 8	
Travelling Expenses	23 6 0	
Subscriptions to National Central Library and A.S.L.I.B. ...	4 4 0	
Accountants' Fees	63 0 0	
Gold Medal	18 19 4	
Office Furniture and Fittings, including repairs	203 2 4	
I.A.U. Telegram Service	10 10 10	
House Expenses	96 1 1	
Meeting Expenses	53 17 8	
Sundries	52 10 11	
		788 17 7
„ Block Subscription to *The Observatory*		142 10 0
„ Purchase of Books from Potter Fund		11 15 6
„ Reserve for Repairs: Annual	40 0 0	
Special	80 0 0	
		120 0 0
„ Binding of Periodicals, etc. (including Reserve)		153 18 6
„ Reproduction of Photographic Slides and Prints		95 15 6
„ Films, Hire and Expenses		18 15 9
„ Manchester Meeting Expenses		14 10 7
		£5,201 11 7

One Year to 1949 *December* 31 *Cr.*

	£ s. d.	£ s. d.	£ s. d.
By *Amounts received from Fellows*:—			
3 Annual Contributions for 1947	6 6 0		
54 " " " 1948	170 2 0		
27 Partial Annual Contributions for 1948 ...	27 11 0		
8 Admission Fees, 1948	16 16 0		
8 First Contributions, 1948	8 8 0		
584 Annual Contributions, 1949	1,839 12 0		
26 Partial Payments, 1949	38 17 0		
4 Institutional Membership Fees	12 12 0		
30 Junior Members' Annual Contributions ...	31 10 0		
57 Admission Fees	119 14 0		
56 First Contributions	123 18 0		
		2,395 6 0	
Composition Fees:—			
Initial Fee	47 5 0		
Initial (Reduced) Fee	45 13 6		
Reduced Fees	107 2 0		
	200 0 6		
Less Refund of overpayment in previous year	12 6		
	199 8 0		
Less Transferred to Reserve Account ...	199 8 0		
	— — —		
Add Amount brought to Credit for the year	131 8 10		
		131 8 10	
			2,526 14 10
" Annual Donation under Covenant			27 10 0
" Interest and Dividends received (gross)		942 4 1	
" Interest on Bank Deposit Accounts received		117 0 2	
			1,059 4 3
" Sales of Publications, Photographs and Miscellaneous Receipts for the year			1,324 15 5
" Royal Society, Grant towards Expenses of Library...			150 0 0
			5,088 4 6
" Deficiency, one year to date			113 7 1
			£5,201 11 7

Note.—Fellows' 1949 *Contributions not received were*:—

	£ s. d.
64 Unpaid at 1949 December 31 at £3 3*s.* 0*d.*	201 12 0
Balance payments required at 1949 December 31 to complete contributions	34 4 0
Total for the year	£235 16 0

This amount has been added to the Suspense Account and is not included in this Revenue Account.

Balance Sheet

		£ s. d.	£ s. d.
General Fund :—			
As at 1948 December 31		24,263 15 1	
Add R. W. Wright Bequest		25 0 0	
		24,288 15 1	
Less Excess of Expenditure over Income, 1949		113 7 1	
			24,175 8 0
Trust Funds :—			
Capital as at 1948 December 31		6,707 0 3	
Income Balances at 1949 December 31		1,096 11 2	
Income Tax on Trust Funds, 1949 April–December, not yet refunded		19 10 8	
			7,823 2 1
Arthur Stanley Eddington Commemoration Fund :—			
As at 1948 December 31		236 6 8	
Add amount received 1 year to date...		285 18 4	
			522 5 0
Reserves :—			
Repairs and Maintenance:			
As at 1948 December 31	£305 12 3		
Less Expenditure, 1949	230 5 4		
	75 6 11		
Add Set aside 1949 (including £80 special) ...	120 0 0		
		195 6 11	
Sales of Duplicate Books Fund :			
As at 1948 December 31	4 11 7		
Add Books sold	30 10 0		
		35 1 7	
			230 8 6
Composition Fees Reserve Fund :—			
As at 1948 December 31		1,991 5 9	
Received in 1949		199 8 0	
		2,190 13 9	
Less 6 per cent transferred to Revenue Account		131 8 10	
			2,059 4 11
Staff Pension Fund :—			
As at 1948 December 31		488 2 1	
Add Interest for 1949		12 4 0	
			500 6 1
Amounts received in advance :—			
Contributions :			
1950 paid in 1948	4 9 0		
1950 paid in 1949	138 2 0		
1951 paid in 1948	3 3 0		
1951 paid in 1949	1 17 0		
		147 11 0	
Publications, 1950	69 8 0		
Postages, 1950...	5 1 6		
		74 9 6	
			222 0 6
Sundry Creditors for Accounts due but not presented (including provision for printing publications for 1949 and binding periodicals, not yet completed) ...			4,573 5 1
			£40,106 0 2

To the Fellows of THE ROYAL ASTRONOMICAL SOCIETY.

We have examined the above Balance Sheet with the Books and Vouchers relating thereto explanations given to us.

We have verified the Securities representing the Investments and have found them to be

SUFFOLK HOUSE,
5 LAURENCE POUNTNEY HILL, LONDON, E.C. 4,
1950 February 8.

1949 *December* 31

	£	s.	d.	£	s.	d.	£	s.	d.
Investments :—									
General Fund, valued as at 1922 December 29 or subsequent cost ...				24,074	11	1			
Trust Funds, valued at cost				6,707	0	3			
(Market Value 1949 December 31, £32,772)							30,781	11	4
Debtors :—									
General				295	9	7			
Income Tax Recoverable :									
General Fund				135	14	7			
Trust Funds				19	10	8			
							450	14	10
Deposits at Savings Banks :—									
General Fund	£5,712	5	8						
Trust Funds	741	0	10						
				6,453	6	6			
Balance on Current Account at Bank and Cash in Hand :—									
General Fund	2,029	15	7						
Trust Funds (including sales of Duplicate Books Fund £35 1s. 7d.)	390	11	11						
				2,420	7	6			
As per Cash Account							8,873	14	0
							£40,106	0	2

Note.—Fellows' Contributions unpaid at 1949 *December* 31 : £505 4s. 0d. *This amount represents the total of the Suspense Account and is not included in this Balance Sheet.*

and certify it to be correctly drawn up therefrom and in accordance with the information and in order.

SHARP, PARSONS & CO.,
Chartered Accountants.

INVESTMENTS

As at 1949 December 31

General Fund

£2000 Swansea Corporation 3½ per cent Stock.
£6723 10*s.* 3*d.* British Transport 3 per cent Guaranteed Stock, 1978/88.*
£496 Consolidated 4 per cent Stock, 1957.
£1035 Agricultural Mortgage Corporation, Ltd., 4½ per cent Debenture Stock, 1961–91.*
£1000 Hull Corporation 4½ per cent Redeemable Stock, 1952–72.
£700 Birmingham Corporation 3 per cent Inscribed Stock, 1947.
£2280 5*s.* 3*d.* War Loan 3½ per cent Inscribed Stock.
£1156 1*s.* 5*d.* Metropolitan Water Board 3 per cent " B " Stock.
£500 National Defence Loan, 1954–58, 3 per cent Bonds.
£500 Savings Bonds 2½ per cent, 1964/67.
£2118 3*s.* 5*d.* Savings Bonds 3 per cent, 1960/1970. (Holding " A ")
£695 16*s.* 0*d.* Conversion Loan 3½ per cent, 1961.
£2239 13*s.* 8*d.* Treasury 2½ per cent Stock, 1975.
£3050 13*s.* 0*d.* British Electricity 3 per cent Guaranteed Stock, 1968–73.*
£3718 British Gas 3 per cent Guaranteed Stock, 1990–95.*
£500 Commonwealth of Australia 3 per cent Loan, 1972–74.*

Trust Funds

£1004 Consolidated 4 per cent Stock, 1957.
£965 Agricultural Mortgage Corporation, Ltd., 4½ per cent Debenture Stock, 1961–91.*
£491 10*s.* 0*d.* War Loan 3½ per cent Inscribed Stock.
£1160 16*s.* 3*d.* War Loan 3½ per cent Inscribed Stock.
£542 18*s.* 2*d.* Savings Bonds 3 per cent, 1960/1970. (Holding " B ")
£1122 19*s.* 6*d.* Savings Bonds 3 per cent, 1960/1970. (Holding " C ")
£1471 4*s.* 0*d.* Savings Bonds 3 per cent, 1955/1965.

* *Taxed at source.*

GIFTS TO THE GENERAL FUNDS AND PROPERTY OF THE SOCIETY

The John Lee Gift (1836 and 1844): In 1836 John Lee, Esq., LL.D., gave the Advowson of the living of Hartwell; in 1844 he gave the Advowson of the living of Stone, Bucks. In 1879 these Advowsons were purchased by his heir, Edward Lee, Esq., for £700.

The Lawson Bequest (1856): Henry Lawson, Esq., bequeathed to the Society the sum of £200, free of legacy duty.

The Carrington Bequest (1876): R. C. Carrington, Esq., F.R.S., bequeathed to the Society £2000 Consols.

The Lambert Bequest (1877): C. J. Lambert, Esq., presented to the Society the sum of £500 free of legacy duty, being part of a sum of money bequeathed by his father, Charles Lambert, Esq., for scientific purposes.

The McClean Bequest (1905): Frank McClean, Esq., LL.D., F.R.S., bequeathed to the Society the sum of £2000, free of legacy duty.

The Farrar Bequest (1906): The Rev. A. S. Farrar, D.D., bequeathed to the Society the sum of £100, free of legacy duty.

The Parsons Gift (1922): The Hon. Sir Charles Parsons, K.C.B., F.R.S., gave to the Society £2500 War Stock 1929–47, in memory of his father, the 3rd Earl of Rosse, who made the 6-foot reflector, and who died 1867 October 31.

The Grove-Hills Bequest (1922): Colonel E. H. Grove-Hills, C.M.G., F.R.S., bequeathed to the Society, free of legacy duty, his collection of early astronomical and mathematical books up to the year 1700, together with a sum of £250 to cover the expenses incurred by the Society in connection with the books.

The Grove-Hills Fund (1922): In 1922 the Treasurer, Colonel Grove-Hills, collected by his private efforts, with the approval of the Council, a Special Fund to meet the immediate financial difficulties of the Society. The total amount received from all sources (including dividends on the investments representing the fund) has been £1913 1*s*. 11*d*., of which £1480 2*s*. 10*d*. has been invested and is now represented by £535 Agricultural Mortgage 4½ per cent, £423 15*s*. 11*d*. War Stock 3½ per cent, and £695 16*s*. Conversion Loan 3½ per cent 1961.

The Lindemann Bequest (1931): A. F. Lindemann, Esq., bequeathed to the Society the sum of £1000, free of legacy duty.

The Archdeacon Potter Bequest (1933) (*see below*).

The Goodridge Bequest (1936): Captain J. J. L. Goodridge, who died 1936 March 13, bequeathed to the Society the sum of £50, free of legacy duty. In 1937 the bequest was invested in £49 0*s*. 4*d*. War Stock 3½ per cent.

The Herbert Spencer Bequest (1936): Herbert Spencer, Esq., who died in 1903, nominated the Royal Astronomical Society as one of twelve Learned Societies to be eventual beneficiaries of his residuary estate. His estate was wound up in 1936, and the Society's share of the residue amounted to £1241. The conditions of acceptance of the legacy were that the sum received should be spent in certain specified ways by the Governing Body within five years of the date of payment, and might not be used in any way for purposes of endowment. The bequest was finally expended during 1941.

The Lindley Bequest (1937): Miss Julia Lindley bequeathed to the Society the sum of £1000, free of legacy duty, which was received from the Public Trustee in the form of £1156 1*s*. 5*d*. Metropolitan Water Board 3 per cent "B" Stock.

The Stanley Williams Bequest (1939): A. Stanley Williams, Esq., who died 1938 November 21, bequeathed to the Society all his astronomical instruments, books, maps, photographs, manuscripts, etc., together with the sum of £200, free of legacy duty, for the reduction or publication of his observations of variable stars; and also a further sum of £100, free of legacy duty, for the furtherance of astronomy in general or of the Society in particular, in such manner as the Council of the Society may think fit.

The E. W. Brown Trust (1939) (*see below*).

The Plummer Bequest (1946) (*see below*).

The Carder-Davies Bequest (1948): D. Carder-Davies, Esq., bequeathed to the Society the sum of £3000, free of duty and without any condition, other than the expression of a wish that no part be spent on any purpose controlled or suggested by Government. The legacy has been invested in the following way: £1229 11*s*. in British Electricity 3 per cent Guaranteed Stock; £1770 9*s*. in Treasury $2\frac{1}{2}$ per cent Stock, which have been added to the General Funds of the Society.

SPECIAL FUND

The Archdeacon Potter Fund (1933): Archdeacon Beresford Potter, who died 1931 May 10, bequeathed to the Society a 3/88th share of his residuary estate. This legacy was received in 1933, and now stands invested in £300 $3\frac{1}{2}$ per cent War Stock, the cash balance of £17 15*s*. 2*d*. having been expended on the library in 1934. The Council resolved to allocate the dividends from this fund for the purposes of the library.

	£	s.	d.		£	s.	d.
1949 Jan. 1. Balance of Fund ...	16	5	0	1949. Purchase of Books ...	11	15	6
1949. Dividends, War Stock $3\frac{1}{2}$ per cent	10	10	0	1949 Dec. 31. Balance of Fund...	14	19	6
	£26	15	0		£26	15	0

TRUST FUNDS

The Lee and Janson Fund (1834 and 1879): In 1834 John Lee, Esq., LL.D., gave £100, and in 1879 T. C. Janson, Esq., bequeathed £200, the interest to be given to the widow or orphan of a deceased Fellow. These amounts now stand in £309 16*s*. 3 per cent Savings Bonds, 1960/1970.

	£ s. d.			£ s. d.
1949 Jan. 1. Balance of Fund ...	90 14 8	1949 Dec. 31. Balance of Fund :—		
1949. Dividends, 3 per cent Savings Bonds	9 6 0	In P.O. Savings Bank	£40 6 8	
Interest on P.O. Savings Bank Deposit	19 6	At Bank	60 13 6	
				101 0 2
	£101 0 2			£101 0 2

The Turnor Fund and the Horrocks Memorial Fund (1853 and 1876): In 1853 the Rev. Charles Turnor, M.A., bequeathed a sum of £500, which now stands in £430 10*s*. 4*d*. 3 per cent Savings Bonds, 1960/1970. In 1876 the Society received a sum of £38 15*s*., the unexpended balance of a fund collected for the purpose of erecting a memorial in Westminster Abbey to Jeremiah Horrocks: to this the Society added the sum of £55 15*s*., and the whole now stands in £95 13*s*. 2*d*. 3 per cent Savings Bonds, 1960/1970. The interest on these funds is to be used in the purchase of books for the library.

	£ s. d.		£ s. d.
1949 Jan. 1. Balance of Fund ...	4 3 4	1949. Purchase of Books ...	19 3 0
1949. Dividends, 3 per cent Savings Bonds	15 15 8	1949 Dec. 31. Balance of Fund...	16 0
	£19 19 0		£19 19 0

The Hannah Jackson (née Gwilt) Fund (1861): In 1861 Mrs Hannah Jackson (*née* Gwilt) gave £300 Consols, which now stands in £287 3 per cent Savings Bonds, 1960/1970; the interest to be given in medals or other awards in accordance with the terms of the Trust.

	£ s. d.		£ s. d.
1949 Jan. 1. Balance of Fund ...	30 8 3	1949 Gift awarded	25 0 0
1949. Dividends, 3 per cent Savings Bonds	8 12 0	1949 Dec. 31. Balance of Fund...	14 0 3
	£39 0 3		£39 0 3

The Harry Watson Memorial Fund (1923): In 1920 Mrs Watson presented to the Society the sum of £300 as a memorial to her late husband, Lieut.-Col. Harry James Watson, F.R.A.S., the interest on this sum to be used for the purchase of books for the library, such books to be indicated by a special book-plate. This gift now stands invested in £542 18*s*. 2*d*. 3 per cent Savings Bonds, 1960/1970. In 1923 Mrs Watson bequeathed a further sum of £958 17*s*. to the Society, which now stands invested in £965 Agricultural Mortgage 4½ per cent Stock. The Council resolved that these two sums should together constitute a Trust Fund, to be designated *The*

Harry Watson Memorial Fund, to be used for the purchase and binding of books.

	£	s.	d.					£	s.	d.
1949 Jan. 1. Balance of Fund...	424	16	3	1949. Purchase of Books ...				144	15	1
1949. Dividends, Agricultural Mortgage 4½ per cent ...	23	17	10	1949 Dec. 31. Balance of Fund:— In P.O. Savings Bank	£258	0	10			
Dividends, 3 per cent Savings Bonds	16	5	8	At Bank... ...	88	0	0			
Income Tax, 1948 April–1949 April, refunded	19	10	8					346	0	10
Interest on P.O. Savings Bank Deposit	6	5	6							
	£490	15	11					£490	15	11

The George Darwin Lectureship Fund (1926): In 1926 Sir James Jeans presented to the Society the sum of £1000 for the endowment of an annual lectureship, to be called *The George Darwin Lectureship*, the lecture to be on some subject of interest to astronomers, preference being given, in electing a lecturer, to one normally resident outside the British Isles.

This sum now stands in £1004 Consolidated 4 per cent Loan. The income is annually applied to the purposes of the Trust in accordance with the terms of the Deed of Gift.

	£	s.	d.					£	s.	d.
1949 Jan. 1. Balance of Fund...	121	8	10	1949 Sept. Lecture Fee ...				50	0	0
1949. Dividends, Consolidated 4 per cent Loan	40	3	2	1949 Dec. 31. Balance of Fund:— In P.O. Savings Bank	£143	5	1			
Interest on P.O. Savings Bank Deposit	3	9	6	*Less*: Temporary advance from "C" account	28	3	7			
								115	1	6
	£165	1	6					£165	1	6

The A. G. Stillhamer Trust (1937): A. G. Stillhamer, Esq., of Bloomington, Illinois, left all his property outright to Miss Maude S. Capps, of Bloomington; but on account of certain personal memoranda and conversation between Mr Stillhamer and Miss Capps, the latter resolved to carry out what she believed to have been Mr Stillhamer's wishes by the payment to the Royal Astronomical Society of the sum of 2500 dollars in cash, the conditions of acceptance being that the principal is to remain intact in the endowment fund of the Society, and the income therefrom to be used annually* to pay expenses of scientific research or to purchase definite scientific instruments for use in scientific instruction or research. The bequest has been invested in £491 10*s*. War Stock 3½ per cent.

	£	s.	d.					£	s.	d.
1949 Jan. 1. Balance of Fund...	204	0	10	1949 Dec. 31. Balance of Fund:— In P.O. Savings Bank	£107	19	4			
1949. Dividends, War Stock 3½ per cent	17	4	0	At Bank... ...	115	18	0			
Interest on P.O. Savings Bank Deposit	2	12	6					223	17	4
	£223	17	4					£223	17	4

* Miss Capps, subsequently to the initial conditions of the Trust, agreed to the income not being expended annually.

The E. W. Brown Trust (1939): E. W. Brown, Esq., M.A., Sc.D., F.R.S., who died in 1938, bequeathed to the Society the sum of five thousand dollars, and desired that the income from the bequest should be used for assistance in the calculation of accurate orbits of the bodies of the solar system, such income as should not be used for this purpose being used for the general purposes of the Society. The bequest was received in 1939 July, and was invested in £1160 16*s*. 3*d*. War Stock 3½ per cent.

	£	s.	d.			£	s.	d.
1949 Jan. 1. Balance of Fund...	162	4	3	1949 Dec. 31. Balance of Fund:—				
1949. Dividends, War Stock 3½ per cent	40	12	6	In P.O. Savings Bank	£190 18 6			
Interest on P.O. Savings Bank Deposit	4	13	0	At Bank ...	16 11 3			
						207	9	9
	£207	9	9			£207	9	9

The Plummer Bequest (1946): H. C. Plummer, Esq., M.A., F.R.S., bequeathed to the Society the sum of £1000, to be invested and treated as a Trust Fund, the income to be at the disposal of the Council for all purposes, with a recommendation that they should consider the possibility from time to time of helping the Norman Lockyer Observatory. The Society was also named as one of the residuary legatees. In 1947 October, a first distribution, under the terms of the will, of £1500 was received from the Administrators of the Estate, which has been invested in £1471 4*s*. 0*d*. 3 per cent Savings Bonds, 1955/1965; this sum and any subsequent sum or sums which may be received from the Administrators will be used in accordance with the late Professor Plummer's wishes.

	£	s.	d.		£	s.	d.
1949 Jan. 1. Balance of Fund ...	44	2	8	1949 Dec. 31. Balance of Fund.	88	5	4
1949. Dividends, 3 per cent Savings Bonds	44	2	8				
	£88	5	4		£88	5	4

LIST OF PUBLIC INSTITUTIONS AND OF PERSONS WHO HAVE PRESENTED GIFTS (OTHER THAN BY EXCHANGE) TO THE LIBRARY DURING THE YEAR 1949.

The Admiralty
H.M. Air Ministry
Argentina, Instituto Geografico Militar
Association Française d'Observateurs d'Étoiles Variables
Astronomical Society of Mexico
Astronomical Society of South Africa
Astronomical Society of Tasmania
Board of Trade, Technical Information and Documents Unit
British Association for the Advancement of Science
British Council
British Interplanetary Society
British Society for the History of Science
Cairo, Fouad I University
Copenhagen, Nordisk Astronomisk Selskab

Ghent, Sterrenkundig Instituut der Universiteit
Griffith Observatory, Los Angeles
Harvard University Committee on Geophysical Research
Imperial Chemical Industries
International Astronomical Union
International Council of Scientific Unions
Institute of Navigation
Institution of Civil Engineers
Lima, Sociedad do Ingenieros del Peru
Lisbon, Sindicato Nacional dos Engenhieros Geografos
London, Institute of Physics
Los Angeles Astronomical Department, University of California
Lourenço Marques, Technical Statistical Department
Manilla Observatory, Philippines
Mathematical and Physical Society of Egypt
Michigan University, Engineering Research Institute
H.M. Nautical Almanac Office
National Research Council of Japan
New York, Academy of Sciences
Princeton University
Rome, Reale Accademia d'Italia
Royal Society
San Miguel, Observatoria de fisica Cosmica
The Science Museum
Sproul Observatory
Survey of India, Office of the Geodetic Branch
Service de Prevision Ionospherique Marine
Trieste, Istituto Geofisico
Union Radio Scientifique Internationale
United Nations, Department of Social Affairs
United Nations Educational, Scientific and Cultural Organization
Washington, Carnegie Institution
Washington, National Bureau of Standards

Mr C. F. Baeschlin
Dr L. J. Comrie
Mr J. F. Cox
The Rev. Dr M. Davidson
Mr P. Doig
Dr J. W. Goethe
Sir R. Gregory
Miss M. Harwood
Brigadier G. F. Heaney
Professor C. Hoffmeister
Sir H. Spencer Jones
Dr M. Kamieński
Mr G. Keller
Mr J. E. Kerrich
Mr M. A. R. Khan
Dr Hans Kienle
Mr G. Lemaître
Mr D. McIntyre
Dr K. G. Meldahl
Dr M. Mémery
Dr G. Merton
Dr S. A. Mitchell
Mr C. T. Moss
Mr M. Nicolet
Lady Flinders Petrie
Mr D. H. Sadler
Dr T. J. J. See
Dr E. Vandekerkhove
Dr G. Walén
Dr G. J. Whitrow
Dr R. Wildt
Professor E. Zinner

CELESTIAL PHOTOGRAPHS

The following have been added to the list of Celestial Photographs reproduced by the Society as slides and prints for sale to Fellows :—

Serial No.	R.A.S. Ref. No.	
528	B 30	Solar Prominence. Climax, Colorado. Roberts. 1946 June 4, $16^h 3^m$.
529	B 31	Solar Prominence. Climax, Colorado. Roberts. 1946 June 4, $16^h 36^m$.
530	B 32	Solar Prominence. Climax, Colorado. Roberts. 1946 June 4, $16^h 51^m$.
531	B 33	Solar Prominence. Climax, Colorado. Roberts. 1946 June 4, $17^h 3^m$.
532	B 34	Solar Prominence. Climax, Colorado. Roberts. 1946 June 4, $17^h 23^m$.
533	J 98	Andromeda Nebula. Harvard–Oak Ridge. Jewett-Schmidt telescope.
534	I 52	Great Nebula in Orion. Harvard–Oak Ridge. Jewett-Schmidt telescope.
535	I 53	Nebula in Cygnus. Harvard–Oak Ridge. Jewett-Schmidt telescope.
536	E 120	Neptune and Satellite. Melotte. Greenwich. 30-inch Refl., *f.l.* 137 inches. 1905 November 5 and 7.

OBITUARY NOTICES

CHARLES ANTHONY, eldest son of Charles Anthony, late of the 16th Lancers, by his wife Elizabeth, daughter of John Warington, was born at the Mansion House, Hereford, on 1865 October 10. He attended the Hereford Cathedral School until he was thirteen and was afterwards educated by private tutors.

In 1886 he was articled with Mr James Mansergh to study sanitary engineering and in the same year was admitted as a student of the Institution of Civil Engineers. During the next three years he travelled throughout the country gaining experience in the design of water supply, drainage and sewerage schemes. After spending a year as Engineer in Charge, under Mr Mansergh's direction, of the Worthing Pier Extension Works, he sailed in 1890 to Buenos Aires as an Assistant Engineer. The government in Buenos Aires employed him two years later as Engineer of the First Class and in 1893 he became Principal Resident Engineer, which post he retained until 1902.

In 1902 Mr Anthony returned to the United Kingdom and a year later was selected by the Cape Colonial Government as Consulting Engineer to investigate and decide on the best source of water supply for East London, South Africa. While there he held in 1904 an examination for associate membership on behalf of the Council of the Institution of Civil Engineers. From South Africa he sailed direct to Buenos Aires to become Legal Representative and Chief Engineer in the construction of the Bahia Blanca Water Works and in 1908 he became General Manager. During his tenure of the post he travelled extensively throughout South America advising on and introducing new water supply and sewerage systems, using the many improved methods of his own design.

Mr Anthony was a man of wide scientific interests, among which archaeology and astronomy always held first place. His interest in astronomy began at an early age, and when at Cambridge with his tutor, the Dean of Clare College, he was fortunate in having the friendship of Professors Freeman and Maine of St John's College, with whom he began observing, making use at first of an old Gregorian 4-inch reflector, replaced in 1884 by a 6½-inch silver-on-glass equatorial reflector by Calver, and he often followed the figuring of these specula by his friend, the celebrated George With. He visited the Royal Observatory, Greenwich, the Cambridge Observatory, then under the direction of his old friend Sir Robert Ball, the Radcliffe and University Observatories, Oxford ; and outside England, the Royal Observatory, Cape Town, then under the direction of that most lovable of men Sir David Gill, the observatories of La Plata and Cordoba in the Argentine, those of San Cristobel, Quinta Normal and Espeja in Santiago, Chile, and that of Rio de Janeiro in Brazil.

In 1901 his paper " A New Form of Reflecting Telescope " was published in *Monthly Notices*. He also was interested in stellar colour determinations and in optical problems both in astronomy and in other connections.

Although he cannot be said to have been fond of sports, he occasionally played cricket in minor events for his county, was a fair lawn-tennis player and a good skater. His favourite forms of recreation, however, were undoubtedly rowing, sculling and Canadian canoeing, and this is not surprising in one who had lived for many years close to so beautiful a river as the Wye.

Mr Anthony married, in 1892 at Montevideo, Frances Mary, sixth daughter of Edward Vincent Heward of Rugby, by whom he has an only son, Charles Warington Anthony.

He was elected a Fellow of the Society in 1901 January 11.

ARNOLD BUXTON was elected a Fellow of the Royal Astronomical Society in 1922 February. His greatest interest in astronomy centred on the mathematical problems connected therewith, but he devoted a fair amount of time, with the aid of the 12-inch reflector at the Penylan Observatory, Cardiff, to educating school parties and members of the public in this subject.

He was educated at Merton College, Oxford, taking his degree in 1914, and was exceptionally well qualified in mathematics. He joined the Army in 1917 and served for a while in the Royal Garrison Artillery but was later posted to the Munitions Inventions Department at Portsmouth.

On returning to civilian life after the first World War, he became a Lecturer in Mathematics at the City and Guilds College, London, which position he held from 1919 September to 1921. Later, in 1921, he was appointed Head of the Mathematics Department at the Technical College, Cardiff, a post which he held until his death. Whilst at this College, he was Acting Principal from 1945 to 1946 and Vice-Principal from 1947 onwards.

He published a number of papers on the theory of optical systems, and his last publication, in the *Philosophical Magazine* for 1947, concerned a method of ray-tracing through thick lenses and across aspherical surfaces.

His loss will be regretted by his many friends, in particular those of the Cardiff and District Astronomical Society, with whose activities he was closely associated just prior to his death.

T. W. WILLIAMS.

PHILIP HERBERT COWELL was born at Calcutta on 1870 August 7. He was educated in England, first at a private school at Stoke Poges, whence he went to Eton as a King's Scholar. At an early date he showed unusual mathematical ability, gaining the Tomline Prize in Mathematics at school and proceeding to Trinity College, Cambridge, with an entrance scholarship. He graduated as Senior Wrangler in 1892, the third on the list being the late Mr S. S. Hough, who became H.M. Astronomer at the Cape. In the following year he was placed in Class I Division I of Part II of the Mathematical Tripos and in 1894 he was elected a Fellow of his College.

In the meantime his studies had turned to astronomy. In 1891 he was awarded the Sheepshanks Exhibition and three years later the Isaac Newton Studentship. His interests were confined to mathematical astronomy, and his earliest research dealt with the investigation of the motion of the Moon by the method introduced by G. W. Hill. The importance of Hill's work had earlier been pointed out by Sir George Darwin to E. W. Brown, who was four years senior to Cowell, and the same influence undoubtedly determined the direction

of Cowell's work. Cowell and Brown met in 1894, while Brown was on a visit to Cambridge, and Cowell assisted in the proof-reading of Brown's volume on *Lunar Theory*. The research for which Cowell was awarded a fellowship of his college was on the calculation of the inclinational terms of the Moon's motion, including the part of the motion of the node which contains the square of the inclination as a factor. This work was published in *The American Journal of Mathematics*, which contained Hill's original researches.

In 1896 Cowell was appointed to the newly created post of a second chief assistant at the Royal Observatory, Greenwich. It was soon found that he had neither the taste nor the aptitude for devising or even using instruments but that he excelled in all matters relating to reducing observations and analysing them. When junior members of the staff were on leave he took charge of their departments and improved the systems of reduction. Amongst his work at this time was an improved method of reducing meridian zenith distances, involving the construction of new tables for refraction based on the Pulkova constants.

The serious difference between the observed and computed positions of the Moon then attracted his attention. Airy had devoted a great deal of time to reducing the Greenwich observations from 1750 onwards and comparing them with tabular values based on his own formula. Observations from 1847 to 1901 had been compared with Hansen's Tables, but for one period of 20 years the wrong sign had been used for one term, while for observations from 1883 onwards corrections determined by Newcomb had been applied. To use the previous reductions effectively it was necessary to reduce them to a common system, and this implied a great deal of work, especially in the case of the early observations. At the time Cowell undertook his discussion it was known that a number of corrections were required by Hansen's Tables, including terms dependent on the action of the planets and on the figure of the Earth. It was known that in a general way the Moon followed the predicted path, but because of the discordances between theory and observation it was thought possible that the theory was not as perfect as it might be. Cowell's work went far to demonstrate that the theory was essentially correct both as regards the inclusion of all the important periodic terms and the coefficients of these terms. The results are given in a series of papers, one of which is to be found in practically every part of the *Monthly Notices* from 1903 November to 1905 June. For the terms of short period Cowell generally used only the observations of 1847–1901, but for longer periods he used the observations back to 1750. The principal papers of the comparisons are in *M.N.*, **65**, p. 108, where the results in longitude are given for 145 terms, and *M.N.*, **65**, p. 721, where the results are given for 101 terms in latitude. For the discussion of terms in latitude Brown's Theory was available, and the enhanced agreement between theory and observation was very noticeable, indicating not only the great accuracy of Brown's Tables but also the accuracy of the coefficients obtained by Cowell from observation.

To complete his discussion of the long-term motion of the Moon, Cowell then turned to the data supplied by ancient records of eclipses. For the secular acceleration of the Moon he found a coefficient of $10''\cdot 9$, which agrees closely with that found by other investigators. He found in addition another term which he at first identified as acceleration in the motion of the lunar node but later attributed to acceleration in the motion of the Sun. In this view he

differed from Newcomb, who placed less reliance on results derived from records of ancient observations, the interpretation of which may be uncertain.

The work by which Cowell is probably best known was done in cooperation with and at the instigation of the late Dr A. C. D. Crommelin. In 1907, when astronomers were looking forward to the return of Halley's Comet in 1910, Cowell and Crommelin undertook the task of predicting its return. The observations made in 1835 fixed the orbit at that time, but to be able to predict the position in 1910 accurately it was necessary to determine the mean motion in 1835 from the observations made at the return of 1759 as well as that of 1835. To complete the work it was therefore necessary to calculate all the perturbations suffered by the comet between 1759 and 1910.

While the calculations connected with Halley's Comet were still being carried out, the discovery of a moving object near Jupiter in 1908 presented new problems to the Greenwich astronomers. After the fact had been established by Dr Crommelin that this was a satellite of Jupiter, it was clear that the solar perturbations could amount to 10 per cent of Jupiter's attractions, and no theory was available which could take account of these analytically. Cowell decided to apply the method of mechanical quadrature to compute the motion direct from the differential equations in rectangular coordinates. Although this merely involved the application of formulae known from the time of Newton, it had not been thought of before. Previously the major portion of the forces had always been allowed for analytically, and mechanical integration had only been necessary for relatively small forces which produced "perturbations" of the orbit determined analytically. As the calculation of perturbations is at best rather complicated, even when they are small, Cowell decided, with great success, to treat all the forces in the same way.

The success of this simple solution for the gravitational problem in the case of the eighth satellite of Jupiter led Cowell and Crommelin to compute the motion of Halley's Comet between 1759 and 1910 by the same method. Before the end of 1908 they had predicted the time of perihelion as 1910 April 16·61, later corrected to April 17·01. The actual time proved to be 2·68 days later. A final revision indicated that errors of computation and application of the attraction of known bodies could not account for more than a fraction of a day.

In 1910 Cowell was appointed Superintendent of H.M. Nautical Almanac Office. He reorganized the work of that establishment and effected a very considerable saving in the cost of carrying out the calculations. At that time Cowell was the outstanding British expert on dynamical astronomy, and it was hoped that his work would lead to a revival of the study of that subject in this country. During the final illness of Sir Robert Ball in 1913, Cowell gave lectures at Cambridge, and it was confidently expected by his friends that he would be elected to a professorship. This was not to be, and Cowell continued to direct the work of the Nautical Almanac Office until he retired in 1930, when he went to live quietly at Aldeburgh in Suffolk. He died of cardiac asthma on 1949 June 6.

Cowell was a great organizer of computing and was himself a very fast and accurate computer. He did all his work by hand, never using a calculating machine. Since his time the calculating machine has been developed to undertake an enormous volume of work which it would have been impossible to undertake by hand. As it happens, the calculating machine is admirably suitable for

and is being extensively used for computing the motion of bodies in the solar system by the method he developed for the eighth satellite of Jupiter and Halley's Comet.

For his lunar work Cowell was elected a Fellow of the Royal Society in 1906 and for that and his later work he was awarded the Gold Medal of our Society and given an honorary D.Sc. of Oxford. After 1914 he never attended any scientific meetings and as he lived at Aldeburgh after 1930 he was personally known to very few Fellows of the Society. He was however warmly attached to Trinity College, Cambridge, and went regularly to the Commemoration celebrations. In 1901 he married Phyllis, daughter of Holroyd Chaplin. She died in 1924. There were no children.

He was elected a Fellow of the Society on 1896 February 14.

J. JACKSON.

MARY ACWORTH EVERSHED was the fifth child in a family of seven born to Captain Andrew Orr, Garrison Artillery, and Lucy Acworth. She was born at Plymouth Hoe on 1867 January 1, while her father was stationed there. Captain Orr died only three years later and thereafter the family lived at their grandfather's rectory, first at Wimborne and later at South Stoke, near Bath. Although " Mindie ", as she was always known, never went to school, she received a good home tuition and was always eager to read all she could find and showed creative talent in writing stories, songs and verses. At the age of 20 she was taken abroad to Germany and Italy. It was in Florence in 1888 that her keen interest in Dante began, which later bore fruit in her book *Dante and the Early Astronomers.* From 1890 to 1895 she was with her mother and three sisters in Australia. In the latter year she returned to England and joined the recently formed British Astronomical Association. Astronomy had been one of her many young interests, but from this time on it became her chief field for serious work. In 1896 appeared her *Easy Guide to Southern Stars*, the need for which had impressed her in Australia. She observed variable stars and went to Norway for the solar eclipse of 1896 and to that of 1900 in Algiers. She also went in later years to the eclipses of 1922 (Wallal), 1927 (Yorkshire) and 1936 (Aegean Sea). Negotiations were under way for her to work at the Dunsink Observatory under E. T. Whittaker, when Astronomer Royal for Ireland (who had married a cousin of hers), when her life was even more firmly welded to astronomy by her marriage to John Evershed in 1906.

Soon after their marriage, Mr and Mrs Evershed left for Kodaikanal Observatory, where Evershed was taking up the post of Assistant Director and in 1911 succeeded C. Michie Smith as Director. The happy partnership produced most fruitful solar research ; in particular, a noteworthy study of the distributions and motions of prominences appears under the joint names of Mr and Mrs Evershed in *Mem. Kod. Obs.*, Vol. 1, Pt. II, 1917. Her one paper in *Monthly Notices*, **73**, 422, 1913, deals with sunspot prominences, and can still be read with much profit since the advent of ciné-photography. It was also at Kodaikanal that Mrs Evershed wrote *Dante and the Early Astronomers.* She accompanied her husband to New Zealand and to Kashmir on expeditions for testing astronomical sites.

In 1923, on retirement from India, the Eversheds returned to England and set up their new home at Ewhurst on the slopes of Pitch Hill overlooking the Sussex Weald, a beautiful site that will be remembered by many astronomers who

visited them there. Mrs. Evershed continued her distinguished services to Historical Astronomy with the formation of the Historical Section of the B.A.A. in 1930, which she directed until 1944. During this period appeared *Who's Who in the Moon*, her bibliographical index to named lunar craters; she also made many contributions to the *History of the B.A.A.*, which was published in 1948. She attended three meetings of the I.A.U., in 1925, 1928 and 1935.

In addition to her literary, historical and scientific interests, her knowledge and love of gardening was evident to all who saw her home. Her gentle and meek temperament endeared her to many friends. But there was a core of firmness and determination in the face of difficulties. The post-war years in an isolated country home entailed considerable hardships. She died on 1949 October 25 after a painful illness.

She became a Fellow of the Society on 1924 May 9 and served many years on the Library Committee.

A. D. THACKERAY.

(GEORGE) CLYDE FISHER was born 1878 May 22 on a farm near Sidney, Ohio, and as a young boy developed a keen interest in the objects of nature. He received his A.B. at Miami University in Ohio in 1905, and in 1926 the degree of LL.D. was conferred upon him by the same University. In 1913 he took his Ph.D. in botany at Johns Hopkins University. He was Principal of Palmer College Academy from 1907 to 1909 and acting President from 1909 to 1910. Later he was an instructor at Cornell and at the Universities of Florida and Tennessee. In 1913 Dr Fisher joined the staff of the American Museum of Natural History, and became Curator of the Department of Public Education in 1928. In 1935 he became Head of the Hayden Planetarium, and in 1941 Honorary Curator. He was a born teacher and loved to give of his time to answer the questions of endless rows of youngsters, and there was no limit to his patience in explaining things in the greatest detail. In his own words, he had been " put up a tree " more frequently by children's questions than by adults'. Dr Fisher took a great interest in the languages and customs of the North American Indians. Twice he visited Arctic Lapland and a number of times the Southwest. In 1936 he went to Siberia as a member of the Harvard–M.I.T. eclipse expedition, and in 1937 to Peru as leader of the American Museum's expedition. Twice in recent years he visited Mexico to study the volcano Paricutin.

He was an excellent and enthusiastic photographer and used his camera on all his trips to collect the material for his educational purposes.

He worked hard to persuade the authorities of the American Museum of Natural History to instal a planetarium, and it was one of his greatest satisfactions that the Hayden Planetarium came into being.

Dr Fisher was a member of the American Association for the Advancement of Science, American Astronomical Society, Association of Variable Star Observers, Society of Research in Meteorites, Amateur Astronomers' Association, Nature Study Society, Torrey Botany Club, Explorers Club. He was a Fellow of the New York Academy, the New York Zoological Society, and the Linnaean Society in New York, and was elected in 1932 to Fellowship of the Royal Astronomical Society. He died on 1949 January 7.

JAN SCHILT.

WILLIAM THOMPSON HAY, son of the late W. R. Hay of Aberdeen, was born on 1888 December 6 and died on 1949 April 18. Shortly after leaving school he joined a firm of engineers, but at the age of twenty-one he gave up engineering as a profession and went on the stage. He soon achieved world-wide popularity in the character he created as a comic schoolmaster, and during the period between the two wars he was one of the most successful and popular comedians on the variety stage. In 1934 he began to appear in films, and in succeeding years he played the leading role in many comedies on the screen. In his professional capacity he toured the world in 1923 to 1924, the United States in 1927 and South Africa in 1928 to 1929. In the first World War he served as an air-pilot and from that time on always maintained a keen interest in aviation, possessing and flying his own aeroplane. In the second World War he served in his professional capacity in the Special Branch of the R.N.V.R., but owing to a severe illness he had to resign his commission. However, in 1945, when he was sufficiently recovered, he became a Lieutenant in the Sea Cadet Corps, instructing the cadets in navigational astronomy. Shortly after the war, in 1946, he had a second serious illness from which he never fully recovered and was forced to give up all active work both in his profession and hobby. However, he continued to attend astronomical meetings whenever possible until a few months before his death.

From an early age he had been interested in astronomy, but it was not until 1932, when he joined the British Astronomical Association and became a Fellow of the Royal Astronomical Society, that he began to meet other astronomers. Previously to this his astronomy had been confined to star-gazing; but now he realized that he himself might be able to contribute something to the science, both by direct observation and by designing new apparatus, for his original interest in engineering had never deserted him.

At this time he had a 12½-inch Calver reflector and a 6-inch refractor by Cooke, mounted in his home-made observatory at Norbury. On 1933 August 3 he announced the discovery with his refractor of a large white equatorial spot on Saturn. This discovery was in no sense due to luck, nor one which anyone might have made had he chanced to look at the planet. Many astronomers must have observed Saturn at the time without noticing it; its detection implied a thorough familiarity with the appearance of the planet as well as considerable observational ability. A great many observations of this spot were obtained and gave us one of the most reliable determinations of the rotation period of Saturn's equatorial zone. His main observational work, however, was the visual determination of cometary positions with an accurate cross-bar micrometer of his own making. These he contributed regularly to the Comet Section of the British Astronomical Association and they were used extensively in the determination of cometary orbits. He also did a certain amount of cometary photography. In 1932 he published a paper in the *B.A.A. Journal* on "A Simple Chronograph", which he made from Meccano parts and a gramophone motor; and two years later he produced a second paper on an improved model of the same instrument. He made several of these instruments, both for his own use in connection with his cross-bar micrometer, and as gifts to some of his astronomical friends. Shortly after this he designed and built a "blink microscope", which though of the simplest construction works perfectly and is easy to adjust and manipulate. Unfortunately he never published a description of this instrument,

though he later generously presented the original model to the British Astronomical Association.

Though publicity was necessary to his professional career he was in private life a most modest and retiring individual. His interest in astronomy, which he regarded very seriously, he was determined to keep as part of his private life; he dreaded the possibility that, should it become generally known, it might be used in an undesirable way to increase his popularity on the stage. He therefore kept his hobby as a closely guarded secret, and it was undoubtedly for this reason that he only got to know his fellow astronomers at a comparatively late stage in his career. For the same reason it was several years before his friends could persuade him to publish his little book, *Through My Telescope*, which finally appeared in 1935. Following his discovery of the spot on Saturn it was impossible any longer to keep his hobby a secret. However, when the first excitement over the astronomer-comedian had died down, the press on the whole were good enough to respect his wishes in this matter and avoid unnecessary references to his hobby.

Hay's death has robbed astronomers of a keen observer and one skilled in the designing of astronomical apparatus, and from many it has taken a good and kind friend. He leaves a widow, a son and two daughters.

He was elected a Fellow of the Society on 1932 November 11.

R. L. WATERFIELD.

EDMUND SEWALL MANSON was born at Scituate, Massachusetts, on 1875 December 1. He studied at the Massachusetts Institute of Technology where he graduated M.Sc. He was a computer at the Lowell Observatory from 1899 to 1901, when he became Assistant at Harvard College Observatory.

In 1907 he became a member of the faculty of Ohio State University and continued there until he retired as Professor Emeritus in 1946, having been Director of the Emerson McMillin Observatory for the previous 24 years. He served in World War I as a Captain from 1917–1919. He specialized in the systematic and preferential motions of stars, making use of proper motions, parallaxes and radial velocities, and also in galactic rotation.

After his retirement he moved to Washington and was there engaged in part-time work for the United States Naval Observatory. He died on 1949 January 29.

He became a Fellow of the Society on 1909 March 12.

JOHN HENRY REYNOLDS, by whose death on 1949 November 22 the Society lost an ex-President, ex-Treasurer, and devoted friend for half a century, was an outstanding example of services rendered to astronomy by someone whose official occupation lay outside the scientific professions. Born in 1874, he was son of a subsequent Lord Mayor of Birmingham, and was one of several contemporary members of its King Edward School (including the Bishop of Birmingham) who have made a lasting mark on national and local life. Although keenly interested in astronomy and in music as a boy, he separated from many less promising schoolfellows by going directly into business instead of to a university; but his labours in design and building of his observatory at Low Wood, Harborne, his many pilgrimages to overseas observatories, including long periods of photographic research at Helwân, and his thirty years of administrative

work for the R.A.S., showed that even the routine and anxieties of a large-scale enterprise in the Birmingham metal industries could not blunt the edge of a purely scientific mind and a simple conscientiousness over public service.

His published researches in *Monthly Notices* (17 papers are in the index of 1911–1931 alone) indicate that if he had chosen a university career he would have been a great investigator and academic leader; but if the astronomers had thereby gained more knowledge of the nebulae, they might have missed another of his generous gifts—the never-failing hospitality to visiting scientists which he and Mrs Reynolds were able to offer from their position in the Midland industrial and social world. Indeed, astronomers from many countries came to Birmingham to visit the Reynolds at Low Wood: at his funeral a recent President of the R.A.S. representing the Society was intrigued to realize in what a long succession of past presidents and overseas astronomers he was standing at that moment—a distinguished line of previous visitors in the history of that hospitable house. It is easy to recall scenes, grave and gay, over many years:—Eddington, in Birmingham to give a lecture, ill and only kept on his feet by the skilled ministrations of Mrs Reynolds, who is never dismayed by anything; Jeans, more engrossed in testing the fine organ in the house than in the lecture he was to give; Dyson, the Astronomer Royal, Jackson of the Cape, and many others occasioning the familiar call from Reynolds: "We have a visitor here from a great observatory, will you come along and be introduced?" Perhaps the most vivid picture is of de Sitter from Leiden, most fascinating of astronomers, arguing in the Low Wood music room about relativistic cosmology and his dislike of nineteenth-century music, until Reynolds set out to convert him by playing the organ chorale-preludes which Brahms had written at the end of his life. The success of those memorable occasions depended upon the unique genius of Mrs Reynolds for making each visitor feel the warm friendliness of the house in between the insistent technical questionings of "J.H.", a task which would have defeated any hostess of less skill in handling academicians and foreigners who might turn out to be as shy or awkward as they were learned.

In addition to this reputation for hospitality, known throughout the entire International Astronomical Union, Reynolds will be remembered for three more formal types of contribution, his own researches on photometry of galactic nebulosity and the external galaxies, his shrewd management of the R.A.S. treasury at a time when any weakness in business judgment would have wrecked the Society's finances, and his building of large reflectors and then donating them to other observatories. There were therefore "Reynolds" telescopes in Egypt and Australia. Most famous, perhaps, is the 30-inch at Helwân, which, in his own hands and under the directorship of Knox-Shaw, did great pioneer work in nebular photography. Of his own papers, possibly those on the angular distribution of external spirals relative to the plane of our own galaxy may have exerted the most influence—a sting and a goad to cosmologists which he was to employ finally in the last few moments of his life. It seemed strange that his Presidential Address to the R.A.S. in 1936 should be on galactic nebulosity, but to that topic also he had contributed many original papers based on his own photography and spectrophotometry: the address set problems which are not yet exhausted, as did his masterly Council Note on external galaxies in 1938, both of which expressed his healthy refusal to be carried away by any theories unless the more precisely observable facts were fairly faced.

After Birmingham's street lighting and the development of large reflectors in better climates had decided him not to build any more telescopes of his own, he installed a Hartmann microphotometric equipment at Low Wood, and made valuable investigations concerning distribution of nebulosity, on plates sent to him from the Pacific Coast, where his judgment was regarded with profound respect. But during the second World War the national need of metal products and alloys kept him at pressure of overwork in his factories, which was amazing for the age of seventy, and astronomy had to take a back place. Even in the last years, however, the Society in its financial anxieties recalled him for consultation, and he loved to keep up his attendance at the Royal Astronomical Society Club. A series of post-war business visits to South Africa enabled him to see his old collaborator Knox-Shaw, and to bring back detailed accounts of the progress of the great 74-inch reflector at Pretoria. In 1949, after a series of severe heart attacks, he had to consent to stay at home, restive and protesting against idleness but full of lively help and stimulus to astronomical visitors; while Mrs Reynolds continued to cope with visitors and host too, under difficulties which would have crushed anyone else. When Professor Dingle, an old friend, came to give the Norman Lockyer Lecture in Birmingham on November 22, Reynolds demanded medical permission for accepting the University's invitation to honour the gathering, and in discussion at the end of the lecture he attacked with exhilarating vigour the uncertainties about galactic distribution. He sat down, having as usual thrown a sobering and unanswerable problem into the arena; and as the audience dispersed a few of them noticed that he was apparently tired and dozing off to sleep where he sat. No one realized for some minutes that he had actually spoken his last word. We were all grateful that he had died without ever knowing he was acutely ill, and that he was not to face the ordeal of helpless inactivity: Mrs Reynolds, as always, has set us the example of courage in a stricken situation. Indeed, there is further comfort, a generation and two generations younger; for he had great delight, the last year or two, in a musician grand-daughter who played in his house the organ he had demonstrated to Jeans. He also had the exhilarating companionship of a younger grand-daughter with mathematical promise, attending an astronomical course in which he himself collaborated.

His association with the Society dated from election to Fellowship in 1899 and included service on Council most years from 1920 onwards, Treasurership 1929–35 and 1937–47, and Presidency 1935–37.

MARTIN JOHNSON.

CHARLES FREDERICK ORTMANN SMITH was born at Edinburgh of Orcadian descent on 1874 September 10.

From an early age he was interested in astronomy and this brought him into touch with astronomical circles in Great Britain and abroad.

He published many papers, chiefly of a selenographical nature, in the *B.A.A. Journal*—a number were illustrated by his own drawings based on many hours of observation at his telescopes in his own back garden. At the time of his death he was a member of the consultative committee of the B.A.A. Lunar Section, and some of his careful and accurate drawings appeared in the Section *Memoirs*. His services to selenography were commemorated by the attachment of his name to a lunar crater in the 300-inch map of Wilkins (1946).

He had been a member of the earlier East of Scotland Branch (Edinburgh) of the B.A.A. When this Branch was dissolved and later on the Astronomical Society of Edinburgh was founded, C. F. O. Smith was one of its most active and helpful members and was Director of the Lunar and Planetary Section of this Edinburgh Society.

In addition to his interest in astronomy he was an artist in oil, water colour and black and white, and examples of his work were frequently hung in the Royal Scottish Academy, the Glasgow Institute and, in 1918, The Royal Academy.

He was connected with the Insurance Company—Scottish Provident Institution—for 55 years and, although due to retire, continued during the war years.

A modest and kindly man, he was ever ready to encourage and help the beginner in astronomy; and his death, on 1949 July 23, was a great loss to his many friends and to astronomy in general.

He was elected a Fellow of the Royal Astronomical Society on 1935 April 12.

H. P. WILKINS.

CYRIL YOUNG died suddenly at Hexham, 1949 September 22. He was seventy-four years old and led a characteristically vigorous life up till a few days before his death.

On leaving Kingsbridge Grammar School in Devon, Young served his apprenticeship with J. Fowler and Co. at Leeds, where he walked two miles to work every morning, starting at 6 o'clock. From here, he passed on to T. Cooke & Sons, where he spent four years, obtaining experience in the manufacture of astronomical telescopes and surveying instruments. In 1901 he joined the staff of the Cambridge Instrument Co. at Cambridge, and in a short time became Works Manager for the Company.

Among his many friends at Cambridge was Sir Robert Ball who, he relates, at that time drove about Cambridge in an astonishing motor which he called his "Transit Instrument". It was through an Irish friend at Cambridge that Young obtained an introduction to Sir Howard Grubb, and presently in 1910 April he moved to Rathmines where he settled and joined Sir Howard as chief designer.

Here was begun the work which was to occupy him for the rest of his life and which he loved so much. He was responsible for the design and construction of a number of telescopes, among them being the 26-inch refractor for the Union Observatory at Johannesburg, and the one-metre reflector at Simeis. Periscopes for submarines were a standard product of the works, and during the first World War Grubbs were the principal manufacturers for the Royal Navy. Many contributions to their design were made by Young. Towards the end of the war it was decided to move the works from Dublin to St. Albans, and in due course this move was made.

In 1924 Sir Charles Parsons purchased the business from Sir Howard Grubb and established the Optical Works at Walkergate, Newcastle-upon-Tyne, appointing Young as Manager; this was the beginning of a firm friendship between them. As general manager of Sir Howard Grubb, Parsons & Co., Young was able to devote his time once again to the construction of astronomical telescopes and up till his retirement in 1945 a total of ten large instruments were constructed at the works and erected in various parts of the world. At the time

of its construction the 74-inch reflector at Toronto was the largest in the British Empire, and it was a great pleasure to him to have attended the opening ceremony at the Observatory.

After he retired, Young maintained his interest in telescopes and paid many visits to the works, where he was always most welcome and his advice sought on many matters. At home he continued to play golf and lead an active life in the garden. He also found time to complete a most beautiful clock, on which he had spent many years in his workshop. Young was a natural engineer with an instinctive insight into engineering problems and a remarkable ability for providing a neat solution. He possessed a sound knowledge of kinematic design principles and knew to a nicety how far they could be put into practice in large instrumental equipment.

He married in 1905 Miss Eileen Robinson, who survives him. His loss will be felt by his many friends to whom he had endeared himself by his charming manner and good humour. He was elected a Fellow of the Society 1929 March 8.

G. M. SISSON.

PROCEEDINGS OF OBSERVATORIES

Royal Greenwich Observatory

(*Director, Sir Harold Spencer Jones, F.R.S., Astronomer Royal*)

Meridian Department.—The restricted programme of observations with the Airy transit-circle has been continued. From March 21 the programme was enlarged to include stars to be used with the photographic zenith telescope at Herstmonceux, together with stars around the zenith contained in the FK3 catalogue on which the P.Z.T. stars are to be based.

Observations made during the year include 150 of the Sun, 92 of the Moon, 38 of Venus, 31 of Jupiter, 41 of other planets or asteroids, together with 1931 transits and 631 zenith distances of standard stars, 1939 transits and 1930 zenith distances of P.Z.T. and FK3 stars.

Shortage of staff still retards the preparation of the First Greenwich Catalogue of stars for 1950.

Alterations to the eye-end of the reversible transit-circle, mentioned in last year's report, were carried out in the workshop and completed in July last. Counterpoising the ZD frame has resulted in a further reduction in its performance-errors. The method of fixing the inner tube containing the eye-end has been modified. Two spring-loaded plungers have been inserted to give three-point bearings at each end.

The apparatus to support a new mercury bath above floor level from the piers has been constructed. Serious refraction troubles were experienced with the old arrangement, in which the bath was supported below floor level from the base-plate, when the temperature below the floor was higher than that in the pavilion.

For each circle microscope progressive errors are being determined. A screw tester of new design has been constructed to facilitate the determinations. The progressive errors will be checked by the variation of runs given by each microscope from observed data obtained over the last few months.

Astrometry and Astrophysics Department.—The remainder of the 113 plates of the Cape zone $-56°$ to $-60°$ have been completely measured and reduced during the year. In all, 7630 stars have been measured, each on at least two plates; about 15 per cent of this total appear twice further on long-exposure plates of sparsely populated regions. With the aid of modern Cape meridian places, measured positions for most of the catalogue stars have now been reduced from the La Plata system, which was the only one available at the inception of the work, to the Cape system; position errors are currently being applied over the whole zone.

The programme of photographing the ultra-violet spectra of late-type binaries has been completed as far as possible on the three-prism spectrograph attached to the Yapp 36-inch reflector, and the one-prism train has been in use since November on fainter stars. During the year 154 spectra of 90 stars were secured on the higher dispersion, and 27 spectra of 8 stars with the lower. A modest increase of staff has enabled arrears to be made good in recording microphotometer tracings of spectra obtained in previous years; and the

records are being examined to study luminosity differences at Ko and the incidence of emission in the H and K lines.

In the last two months of the year micrometer measurements of position of the minor planet Metis were made with the 7-inch guiding telescope attached to the Yapp reflector. The ephemeris in *Minor Planets for 1949* and its revision in *J.B.A.A.*, **59**, 254, 1949 were found to be wrong by 1° and 9′ respectively at the end of November, and a new orbit has been computed which satisfactorily represents the 13 observations made since then.

A new system of supports for use in the metallizing plant now makes it possible to aluminize any of the eclipse coelostat mirrors in the United Kingdom.

Time Department.—The Time Service continued to be operated from Abinger in 1949, with Greenwich available as reserve for some facilities. The astronomical observations on which the service was based were made at Abinger (with the Bamberg broken transit) and at Greenwich (with small transit " B "). A normal time observation comprises ten star transits. An attempt is made to secure two such observations on each clear evening at each station, and sometimes three or four observations have been obtained in one evening by two observers working on one instrument. Some new observers have been trained at each station, but their observations have not been used until a reasonable standard of internal agreement has been attained. The number of observations actually used for the determination of clock performance was 508, made up as follows :—Abinger, 305 observations on 172 nights; Greenwich, 203 observations on 145 nights. The total number of observations used has continued to rise in recent years, and this is the first time that it has exceeded 500.

The quartz clocks used are all of Post Office design, and are situated at Abinger, Greenwich, Dollis Hill and Banbury. The figures from the last two stations are supplied by courtesy of the Engineer-in-Chief, Radio Branch, G.P.O. Promising results have been attained at Dollis Hill from some new oscillators employing ring crystals. Data relating to quartz clocks at other establishments are received regularly, the figures providing a valuable auxiliary check on the service maintained by the Department.

In October the Dent regulator clocks which had transmitted the B.B.C. " Six-Pips " signal and the G.P.O. hourly signal for over 25 years were relieved of this task; these signals are now transmitted by special phonic motors directly controlled by the standard quartz clocks. A number of foreign time signals were received throughout the year, but owing to staff shortage it became necessary to discontinue the reception of the 20.00 U.T. American and French signals. About six transmissions are measured each working day, including signals from Paris, Washington, Moscow, and (recently) Hamburg and Canberra.

The daily standard frequency transmissions from Abinger continued to prove of great practical value to many Government departments and commercial research establishments. Corrections to these and other transmissions are distributed regularly. New equipment for frequency measurement is in process of design and construction. Special receivers and recording equipment were constructed for the proposed series of transatlantic experiments for the determination of the velocity of propagation of long-wave radio, but owing to unexpected difficulties in reception at the U.S. Naval Observatory, the programme is temporarily postponed. Development work is proceeding on divider circuits, quartz-crystal oscillators, and new control equipment for the 2 Mc./s. transmitter.

A significant advance in technique towards the end of the year was the introduction of corrections for the annual variation in the rotation of the Earth. The application of these corrections, which have maximum values of ± 60 milliseconds, substantially improves the assessment of clock performance in terms of the astronomical observations, and has also justified the use of provisional corrections for polar variation. The full effects of these modifications should become apparent during the coming year, and a significant advance in the accuracy of frequency determination should be achieved.

Optics Laboratory.—Work on the P.Z.T. has continued throughout the year. The essential features of the instrument were for the most part decided upon in principle at the time of the previous report; the minor addition since that date has been the provision of a simple optical system for determining the effective magnification of the chronographic record so that the absolute value of the speed of the carriage can be determined. There has, however, been a considerable amount of work, both theoretical and in detailed designing, required to put into practical form the general principles already agreed upon. Some further experimental trials have also been made. Details of the time sequence, of the rotary carriage clamps, of the chronograph, of the reversing mechanism and of the auxiliary electrical control and indicating systems have received attention. The stellar shutter has been re-designed on a somewhat new principle in order to make its obstruction of the aperture symmetrical, since the effect of asymmetry in conjunction with error of focus is to produce an error in the results, which, though not large, is systematic. The design is mechanically simple and has been successfully tried in model form. Attention has also been devoted to the design of the foundations, of the observer's platform, and of the building. Considerable progress has been made in actual construction of the instrument.

Solar Department.—The Sun was photographed on 286 days. Up to November 30, there is no day unrepresented in the combined series. Cape negatives have been received in duplicate up to 1948 December 31. A negative for 1948 July 24 has been received from Kodaikanal, and the remaining gap in the combined series for 1948 is now represented by a positive for December 20 kindly sent from the U.S. Naval Observatory, Washington.

The measurement of the combined series has been made from 1946 February 15 to 1947 January 7. Tables of the mean daily areas and mean latitudes of sunspots for each solar synodic rotation in 1943 and 1944 have been published in *Monthly Notices* 1949. The *Greenwich Photoheliographic Results* for 1938 are being reproduced by photolithography from copy prepared on a varityper.

The 4-inch photoheliograph was moved from Greenwich to Herstmonceux on May 2 and mounted on the Newbegin telescope which had been set up in the new solar building on April 25. A new exposing shutter on the general lines of the old one, but with an electric release, had been made for the photoheliograph before removal to the new site. Many of the plates taken at Herstmonceux are of good definition and clearly show the photospheric granulation.

The Sun's disk was observed at Greenwich in $H\alpha$ with the spectrohelioscope on 195 days; on 33 of these, observation was possible only for fifteen minutes or less. 277 measures for any small line-of-sight motions were made on normal and flare patches of bright flocculi associated with sunspots, most of these

measures also giving effective line-widths of $H\alpha$. 173 measures were also made on dark filaments on the disk and 31 measures on limb prominences. Line-of-sight velocities for dark filaments exceeded 100 km./sec. in three cases, the highest value being 145 km./sec. inwards to the Sun on August 5. 394 sets of photometer measures were made collectively on normal bright flocculi and flares. 49 solar flares were observed. Those of special interest occurred on February 1, February 11, August 5, September 13 and November 19. The flare on August 5 was followed throughout from its onset at $07^h\ 54^m$ U.T. to its finish four hours later. An account of these observations has been published in *The Observatory*, **69**, 235, 1949.

On June 23, a "sudden-phase-anomaly indicator" was installed in the Solar Department at Herstmonceux. This radio equipment, in recording the combined amplitude of the ground and sky waves radiated by G.B.R. (Rugby) on wave-length 19 km., registers the occurrence of sudden changes of phase difference due to the effect of solar flares on the ionosphere at about the 70 km. level.

The Newbegin spectrohelioscope has been thoroughly overhauled in the Observatory workshop at Greenwich. This instrument will be set up in the solar building at Herstmonceux in 1950 January, and the Greenwich spectrohelioscope will later be erected in the same building.

Nautical Almanac Office.—The Office was transferred to Herstmonceux Castle on October 10, thus ending a long period of "temporary" habitation in Bath. The move to a permanent home, together with the recent filling of some of the long-standing vacancies on the staff, should enable more substantial progress to be made with the outstanding astronomical investigations. The Office particularly welcomes the addition of Dr J. G. Porter to the staff.

A start has been made in overtaking the arrears in the occultation programme; the discussion of observed occultations for the years 1944 and 1945 has been published in the *Astronomical Journal*; that for the year 1946 is in course of publication and that for 1947 should be ready early in 1950.

Although the Office has made every effort to advance the dates of issue of its publications, and composition was actually well ahead of schedule, there have again been considerable delays, outside the control of the Office, in the actual printing. Neither the standard nor the abridged editions of the *Nautical Almanac* for 1951 will be published until early in 1950.

Several changes have been decided in the *Nautical Almanac* from 1952 onwards. The elements of occultations will no longer be given, on the grounds that the Office provides predictions for the great majority of observers: the elements will still be available in the *American Ephemeris* and elsewhere. Apparent places of occulted stars will continue to be given. In view of the introduction of the *Star Almanac*, which will cater for the needs of most surveyors, the apparent places of stars will be omitted from the *Nautical Almanac*; in their place will be given an enhanced list of mean places complete to a specific limiting magnitude. Finally, precise ephemerides of Ceres, Pallas, Juno and Vesta will be included; they are being computed from 1950 onwards, in cooperation with the U.S. Naval Observatory and Cincinnati Observatory, but will be published for 1950 and 1951 as U.S. Naval Observatory *Circulars*.

Work has progressed steadily throughout the year on the preparation of the new *Abridged Nautical Almanac* and the *Star Almanac*. During the year, Mr G. A. Harding did a tour of duty in a surveying ship to gain experience of navigational methods in the Royal Navy.

Royal Observatory, Edinburgh

(Director, Professor W. M. H. Greaves, F.R.S., Astronomer Royal for Scotland)

Stellar Spectrophotometry.—The spectrophotometric studies of early-type stars have been continued with the 36-inch reflector, mainly on stars of types B0 and B1, and on an equal-altitude comparison of the blue Oe5 star 10 Lacertae with the yellow Oe5 star 19 Cephei. 85 spectra, half of which involved exposures ranging from 60 to 100 minutes, have been secured on 44 nights. The efficiency of the work at the telescope has been considerably increased by reliable cloud forecasts supplied early each evening by courtesy of the Air Ministry. This arrangement has reduced the amount of abortive work, since an observer does not commence a long exposure when the forecast indicates that his exposure will be spoilt by cloud. On the other hand, the observer does not abandon his effort for the night if he is informed by the forecaster that the sky will clear.

The programme includes the study of the broad interstellar absorptive region centring at λ 4430 and has now been extended to include the study of the diffuse interstellar line λ 6284. The inclusion of λ 6284 has led to supplementary measures on the Oe5 spectra, which are intended to serve as the basis of the reduction of spectral line intensities of the stars of type B. The number of wave-lengths at which measurements are made in each spectrum has been increased and is now 1500.

A description of the methods employed in this work, together with the results obtained on the seven stars of type Oe5 mentioned in last year's report, were published during the year as Volume 1, Part 2 of the *Publications* of the Observatory.

Variable Stars.—During the year the observations of variable stars made between 1933 and 1939 in Kapteyn's Selected Areas 5, 6 and 7 were published as Volume 1, Part 3 of the *Publications* of the Observatory. Particulars are given of two previously known variables and of seven variables discovered in the course of the work. One of the latter appears to have the somewhat rare period of 41·5 days.

Astrographic Catalogue.—Zones $-40°$ to $-38°$ of this Catalogue, the plates of which were measured at this Observatory, are being reproduced in Paris under the auspices of the International Astronomical Union. M. J. Baillaud, President of Commission 23, is supervising the work of reproduction, and he hopes to have zones $-40°$ and $-39°$ ready for distribution during the current year.

Solar Work.—The Sun was observed in $H\alpha$ light with the combined spectrohelioscope and spectrograph on 214 days. Accurately oriented disk drawings for sunspots in white light were made on 186 days with a 5-inch image. These were employed for recording the positions of flares observed in the spectrohelioscope and for marking the location of the slit when photographing prominence spectra. With the 16-foot spectrograph (dispersion element a 5-inch Rowland grating) 195 calibrated plates of flare and prominence spectra were obtained, mainly relating to $H\alpha$, *He* 5876 and *He* 6678.

A full investigation has been made of the corrections for "ghosts" and for general scattering in heterochromatic light, using the first and second orders of the Rowland grating. The instrumental profile in both orders has also been investigated by means of a series of microphotometer tracings of the line λ 5571 in the light from a krypton tube.

Miss M. Conway, a research student, has continued her investigations of the $H\alpha$ line profile in prominences of various types.

The investigation of the profile of the $H\alpha$ emission line in flares has been continued. During the 3^+ flare of 1949 November 19 a maximum line-width of 23 A. was recorded at $10^h\,32^m$. A plate taken at $10^h\,36^m$, which has been microphotometered, shows the line about 20 A. wide and having a central intensity (corrected for scattered light and ghosts) of 190 per cent of the continuum outside $H\alpha$. This catastrophic broadening of $H\alpha$ coincides with the "flash" of the flare and is evidently inherent in the flare discharge mechanism: the Stark effect has been suggested as a possible explanation.

Associated with the same flare there was an increase in the brightness of the continuous spectrum of the disk in the immediate vicinity of the flare and extending over at least 800 A. of wave-length. The greatest measured value of the enhanced continuum was 108 per cent of the normal continuum, the maximum enhancement being just north of the flare filaments. This enhancement of the continuous spectrum of the disk is similar to that which occurred on the occasion of the 3^+ flare of 1946 July 25 when an enhancement amounting to 110 per cent at peak intensity was recorded. Both of these flares were accompanied by sudden increases of cosmic ray intensity.

41 flares were observed during the year, classified as follows: Class 1, thirty; Class 2, seven; and Class 3 or 3^+, four. Records of all these flares were communicated quarterly to Meudon for inclusion in the *Quarterly Bulletin*, and daily records were supplied to the Radio Section, Cavendish Laboratory. Flares of exceptional intensity have been reported by telegram to Meudon and to the Royal Greenwich Observatory.

With the cooperation of Mr J. A. Ratcliffe and the staff of the Radio Section, Cavendish Laboratory, a long-wave radio receiver has been built, to the Cavendish design, by Messrs Morley and Duke of Cambridge. It was installed at the Observatory in June by Mr F. Gardner of the Cavendish Laboratory. This receiver provides an automatic record of distant atmospherics; it is tuned to 27 kc./s.* and provides immediate warning of the occurrence of all major flares through the increase in the D-layer reflection coefficient. Dr C. B. Childs, of the Natural Philosophy Department, Edinburgh University, has kindly provided records of sudden anomalies in recorded field strength (G.B.R., 16 kc./s.) associated with flares. These and other sudden ionospheric disturbances have been compared with the line-width development curves for the flares observed with the spectroheliscope. This analysis will be published shortly.

Stellar Photometry.—The 10-inch astrographic camera has been removed from the 15-inch refractor mounting in the West Dome and was installed in September on a fork mounting, specially constructed for it by Messrs Cox, Hargreaves and Thomson. The measurement of plates taken with this camera before its removal has been continued. The star actinometer, supplied by Messrs P. J. Kipp and Sons in November 1948, has been used for this work.

Visitors.—Among our visitors during 1949 we were pleased to welcome M. Couderc, Dr R. G. Giovanelli and Professor Otto Struve. The last named was interested to see that the first signature in the visitors' book of the Dunecht Observatory, from which this Observatory derived its library and its earliest instruments, is "Otto Struve, Pulkowa, 1875 Sept 9th".

* Since changed to 22 kc./s. owing to interference at 27 kc./s.

Staff.—The vacancy for a scientific assistant remained unfilled during 1949 (though it has since been filled); but from October the Observatory had the assistance of a clerical officer (Miss A. Brownlee). The staff is otherwise unchanged.

Royal Observatory, Cape of Good Hope

(*Director, Dr J. Jackson, F.R.S., H.M. Astronomer*)

Reversible Transit Circle.—The observation of standard stars for the zones -64° to -80° was completed on November 19. To even up the observations in different right ascensions it was necessary for several months to make observations in the early morning as well as the evening. As is usual with finishing off a programme, the number of observations fell below normal, but nearly every star received the agreed number of four observations, two on each clamp. In all, 3999 transits were observed. These included 256 observations of stars in the daytime and the following observations of bodies in the solar system:

Sun	169	Ceres	7
Moon	21	Jupiter	9
Mercury	55	Saturn	10
Venus	84	Neptune	15

All the observations have been reduced to show mean place for 1950.0. The difference between the observed and tabular positions of the standard stars is being discussed.

The analysis of the observations of the Sun, Mercury and Venus made in the years 1936–1944 is nearly complete, while the comparison of later observations with the tabular places of the Sun and all the planets is complete to the end of 1948.

With the completion of the observations for the zones -64° to -80° the task of altering the instrument to photographic recording of the declinations was taken in hand. In this work we had the advantage of detailed drawings of the apparatus developed at the U.S. Naval Observatory, Washington. The first camera was completed in our own workshops and a complete set of twelve (six for each position of circle east or west) is being made at the Trigonometric Survey Office, Mowbray. The cameras will use standard 35 mm. film and will photograph the circle on a scale of about 16 mm. to the degree—at least one whole degree graduation will show on each photograph.

A new working programme has been prepared. It includes all the G.C. stars between -30° and -52° and between -80° and the south pole. FK3 stars between -20° and -30° have also been included. Observations will be commenced as soon as the alterations to the instrument are completed.

Photographic Zone Observations.—The copy for press for the zones -30° to -35° and -35° to -40° is complete except for the photographic and photo-visual magnitudes which are awaiting reduction to the adopted standards. For zone -52° to -56° (9000 stars) the positions and proper motions have been determined. The plates for the zone -56° to -60° (7630 stars) have been measured at Greenwich, where final corrections to the preliminary positions are

being determined. For zone $-60°$ to $-64°$ (7000 stars) the remaining 41 plates have been measured and the plate constants derived. Standard coordinates have been computed for stars in the first seven hours of R.A. of the zone $-64°$ to $-68°$ and the plates for zones $-68°$ to $-80°$ have all been taken.

Victoria Telescope.—The 24-inch photographic refractor was again principally used for observations for the determination of stellar parallax. The parallax programme is gradually being worked out and the telescope is being used more for photometric work, which has been extended beyond the normal evening and morning hours of observing.

During the year 2310 parallax plates were taken on 241 nights and in addition 62 plates were taken for the determination of proper motion. 2301 plates were measured for parallax and 104 were rejected, leaving 10,035 still to be measured. In addition 16 plates were measured for proper motion in declination. The number of stars for which a parallax has been determined since this work was commenced in 1926 is 1623, and for the most important stars plates have been taken for a second determination. This second determination has been completed for 54 stars. About a third of the 300 stars now under observation have already had a parallax determination here. A list of 100 new determinations and 31 second determinations has been prepared for publication in the *Monthly Notices* of the Society.

Stellar Photometry.—Steady progress has been made with the measurement of the photographic and photovisual magnitudes of the 23,500 stars in the zones between $-56°$ and $-64°$. The measures and reductions to the S system of magnitudes were completed as far as $11^h 40^m$. The plates on which these measures are being made were taken by Dr Redman when he was at the Radcliffe Observatory.

The work on the zone stars was interrupted during July, August and September to determine the photographic magnitudes for 600 parallax and their comparison stars. These magnitudes were required to complete the copy for press of the account of the parallax observations. The method used for deriving these magnitudes is essentially the same as that described in *M.N.*, **105**, 225, 1945, but for this series very much better determinations of the zero point are available from the special observations made with the Fabry photometer attached to the Victoria telescope.

During the measurement of the parallax plates a few variable stars were discovered and they were measured on the whole series of plates on which they appear. At the request of Dr Thackeray of the Radcliffe Observatory, possible variations in the magnitude of Proxima Centauri were investigated. No variation exceeding $0^m{\cdot}10$ could be found on the Cape series of 58 parallax plates extending from 1932 July to 1949 July.

The timing of the exposures with the Fabry photometer attached to the astrographic refractor was made fully automatic during the course of the year. The programme to determine the photovisual magnitudes for 209 stars brighter than $7^m{\cdot}5$ in the E regions was completed in September and attention is now being concentrated on finishing the Bright Star Programme which aims at the determination of an accurate photographic magnitude for all the 850 non-variable stars south of $+6°$ whose HR visual magnitude is $5{\cdot}0$ or brighter. In the course of ledgering the observations for this programme several stars have been found to be variables of small range. In general their variability of magnitude has not

been previously reported, though most of them are stars for which some variability might be anticipated, viz. stars with variable spectra, variable radial velocity or with spectra of a very late type.

The Astrographic Fabry Photometer was in use on 131 nights and some 5500 observations, each of two exposures, were made with it.

The Fabry photometer attached to the 24-inch Victoria refractor continued to be used for the determination of accurate photographic magnitudes for stars between magnitude 5·0 and 11·0 for which the parallax has been determined. It was used also to observe 230 stars in the E regions. These stars, which were mainly between the eighth and tenth magnitude, were specially selected in order to investigate the systematic distance corrections and the variation of colour characteristic with magnitude in the magnitudes derived from plates taken with the photometric cameras. The magnitudes obtained with the Fabry photometer are free from such effects, as the stars are observed individually and the measures are made on images of nearly equal density. The Fabry magnitudes also provide a very useful check on the scale of the S magnitudes. The corresponding programme for the photovisual magnitudes could not be undertaken till the end of the year when the 18-inch lens was returned from England after re-polishing.

The Fabry photometers on the Victoria telescope were in use on 95 nights and 1500 observations were made of the parallax stars and 1700 of stars in the E regions.

The observations with the astrographic telescope to extend the SPg magnitudes to fainter stars by means of plates taken in focus and using a large rotating sector to provide a known magnitude difference were continued. A series of plates has now been obtained for each of the nine E regions. These plates have been measured but have not yet been fully reduced.

The moving plate holder (Schraffierkassette), whose construction was begun in 1948, was completed. It was installed on the 74-inch reflector at Pretoria by Dr David S. Evans. Through the kindness of Drs Knox-Shaw and Thackeray, Mr Cousins was able to go to Pretoria and use this instrument during the months of October and November. The object of Mr Cousins' observations was the extension of the E region sequences to stars fainter than those that can be conveniently observed at the Cape. In all, he obtained 77 plates covering the E regions 8, 9, 1, 2 and 3. Only 12 of these plates have so far been measured and reduced.

Professor Redman has completed his work at Cambridge with our photometric cameras for transferring the International Standards near the north pole to Kapteyn Areas and open clusters observable from South Africa. He is continuing to strengthen the link by photoelectric observations.

The modified Schilt photometer has been in regular use throughout the year and was used in making about 145,000 measures of images for our various photometric programmes.

The photoelectric observations begun in an experimental way in 1948 were continued. Considerable alterations and improvements were made both to the photometer itself and to the 7-inch telescope on which it is mounted and it was not until the end of August that the instrument was ready for a routine programme. The photometer uses a 931-A photo-multiplier tube and two colour filters (blue and yellow) and observations are being made to determine the colours of the 850 stars of the "Bright Star Programme". The colour

index determined photoelectrically is about 0·8 of the International colour index while the magnitudes that would be determined by the use of the blue filter alone would be approximately on the International photographic magnitude system. By this means we will be able to derive the visual magnitudes from the photographic ones determined with the astrographic telescope. On account of variations in atmospheric conditions and lack of uniformity in them, one of the most difficult problems in photometry is that of transferring standard magnitudes from one part of the sky to another and we have found it more convenient to do this by Fabry observations than by photoelectric ones. The accuracy aimed at is $0^{m}·01$ in both colour and magnitude programmes—an attempt at greater refinement being at present unwarranted by practical, probably more than by theoretical, difficulties. To obtain the accuracy aimed at, four observations of the colour of each star will be required.

During 1949 the photoelectric photometer was used on 65 nights and 974 measures of colour were obtained, the majority of these being in the last four months of the year.

A similar photoelectric photometer was constructed and used in the laboratory to check the reduction constants of the rotating sectors used on the telescopes and to measure the transmission curves of colour filters. Experiments were also made with the aim of designing a photoelectric flicker photometer for the direct measurement of star colours.

In the development of our photoelectric work we have had valuable assistance from Dr R. Guelke of the University of Cape Town.

Photoheliograph.—The Sun was photographed on 360 days. In all, 743 plates were exposed. For the determination of orientation visual observations were made weekly and 25 of the plates exposed had double exposures for the same purpose.

The number of days on which plates were taken was easily a record, as the Sun was missed completely on only five days. On two days it was only possible to get one plate. The days on which no observations were secured were April 25, May 16, July 8, August 28 and November 28. The previous best year was 1943 when the Sun was missed on 14 days. It is remarkable that so few days were missed in the winter and especially none at all in June.

The plates are forwarded to Herstmonceux for measurement at the Royal Greenwich Observatory along with plates taken there.

(By an oversight the photoheliograph was not mentioned in the report for 1948. In that year plates were taken on 335 days.)

Occultations.—84 observations of 43 phenomena were made with various telescopes at the observatory. Of these, 67 were disappearances at the dark limb and 17 reappearances, also at the dark limb. The principal observers were Mr Davies (35), Dr Stoy (28) and Mr Cousins (13).

The data from these observations and from 21 observations made by Mr S. C. Venter at Pretoria and a few by other amateur observers in South Africa were sent to H.M. Nautical Almanac Office.

Variable Stars.—During 1949 Mr R. P. de Kock made 5769 observations of 157 variable stars of long period, using a 6-inch refractor. Mr de Kock observes about every fifth night and morning. The observations are forwarded monthly to the American Association of Variable Star Observers at Harvard, and constitute by far the most extensive series of observations made in the southern hemisphere.

Comets.—Observations were continued of Comet 1948 l which had appeared as a very bright comet in 1948 November. As the comet became fainter and longer exposures were necessary to get a measurable image of it, the brightness of the reference stars was reduced by inserting a fogged plate near the focus of the telescope with a clear aperture round the position occupied by the comet. Eleven plates were taken with the Victoria telescope. These were measured along with eight plates obtained at Pretoria with the 74-inch reflector. In all, positions of this comet were determined on 41 nights in the interval 1948 November 8 to 1949 April 2. An accurate orbit has been computed by Mr W. P. Hirst, who besides computing comet orbits has computed orbits for a number of minor planets discovered at the Union Observatory, Johannesburg.

Publication of Observations.—Arrangements have been made with the Hydrographer to reproduce catalogues by photolithography from typescript prepared at the observatory. The typing of the second and third meridian catalogues for 1925.0 and the first for 1950.0 has been completed. These contain the results of meridian observations made in the years 1923–33, 1933–36, 1936–44. An advance copy of the first of these has been received. This has been sent off to Washington, as also a copy of the 1936–44 catalogue, for use in the investigations of the corrections required by the fundamental catalogues, which are being made under the direction of Dr H. R. Morgan. The typing of the details of nearly 1200 parallax determinations has been completed except for the magnitudes of the parallax and comparison stars.

Armagh Observatory

(*Director, Dr E. M. Lindsay*)

Equipment.—The Armagh-Dunsink-Harvard telescope will leave for the Boyden Station of the Harvard Observatory in March. The dome for the Armagh Schmidt arrived and has been erected, as have also the pier and part of the mounting, but we still await the rest of the instrument from the makers. Two special meteor cameras have been constructed in the Observatory workshop, one to be erected at the Observatory, the other some thirty miles away. Two patrol cameras have been obtained and are in process of mounting. The 10-inch refractor has been overhauled in preparation for use on photoelectric problems.

Publications.—Numbers 1 and 2 of a series of "Contributions from the Armagh Observatory" have been distributed. The following papers have been completed and are in the press:—

Contribution No. 3. "Stellar Models with Variable Composition. II. Sequences of Models with Energy Generation proportional to the fifteenth power of the Temperature", by E. J. Öpik.

Contribution No. 4. "The Distribution of Stars brighter than Photographic Magnitude 14·0 between Galactic Longitudes 290° and 360° and between Galactic Latitudes ±30°", by E. M. Lindsay.

Contribution No. 5. "Secular Changes of Stellar Structure and the Ice Ages", by E. J. Öpik.

"Ratio of Total to Selective Absorption", by E. M. Lindsay.

Miscellaneous.—Lectures in the Department of Astronomy, Queen's University, Belfast, were given on two days a week. Meteorological work was continued as usual. Visitors to the Observatory numbered over 1300. A dwelling-house for the Senior Assistant is now completed. The Director spent three months in the United States, during part of which he was at the Harvard Observatory.

Cambridge Observatories

(*Director, Professor R. O. Redman, F.R.S.*)

Staff.—There are again a fair number of changes to report. Mr W. H. Manning, Assistant at the Solar Physics Observatory for 45 years, retired on September 30. Miss R. M. Tuck, Secretary, resigned during August. Mr E. T. Pierce, Junior Observer, returned from prolonged sick leave in March.

Mr D. E. Blackwell, M.A., Stokes Student of Pembroke College, has been appointed Assistant Director of the Solar Physics Observatory. Dr H. von Klüber has been appointed as a Senior Observer, Mr J. P. Hignell as an Assistant, and Miss T. Carter as Secretary.

Dr W. H. Steavenson has continued his voluntary work. Miss B. Middlehurst, M.A., and Mr J. N. Hodgson, B.Sc., gave valuable assistance during the Long Vacation. Mr F. Hepburn and Dr E. Wolf have been working under special D.S.I.R. grants, and Mr R. M. Goody under a Gassiot Committee grant. The following have worked as research students during a part, or the whole, of the year: M. K. M. Aly, I. C. Browne, P. G. F. Caton, B. A. Eagle, P. B. Fellgett, M. G. Fracastoro, J. H. Shaw, L. G. Smith, M. J. Smyth, H. V. Stopes-Roe, P. A. Wayman.

Re-equipment and Reconstruction.—Following a recommendation of the University Grants Committee, H.M. Treasury has approved a grant of £72,000 for the re-equipment of the Observatories. Supplemented by £6000 from University funds, this will provide a new workshop, a 36-inch reflector, a 16–24-inch Schmidt telescope, and will allow reconstruction of the McClean solar installation. Contracts for the new telescopes have been placed with Messrs Grubb, Parsons, and a 38-inch disk of low expansion glass, made by Pilkington Bros., is being tested for its suitability for the principal mirror of the 36-inch telescope.

Buildings.—The conversion of the transit-circle room into a small optical laboratory has been completed. The division of the mural-circle room into two floors and a number of smaller rooms is nearly finished. Plans are well advanced for the new workshop. The temporary accommodation in Short's aircraft factory, used for work in meteorological physics, has been abandoned on account of a serious fire, which fortunately did little damage to observatory equipment.

Solar Research.—22 flares have been observed with the spectrohelioscope, observations being made altogether on 82 days. Line-width development curves for $H\alpha$ were obtained for all suitable flares and the results communicated to the Cavendish Laboratory for comparison with sudden ionospheric disturbances. The instrument has been modified to allow these observations to be

made photographically, but a much more extensive reconstruction of the spectrohelioscope is now contemplated.

A Lyot polarizing filter of quartz (seven plates) and polaroid, working in $H\alpha$, has been constructed and is now in operation on the Thorrowgood 8-inch refractor. Prominences are satisfactorily observed, and the definition is superior to that given by the spectrohelioscope. Dark markings on the disk are not, however, easily visible; they apparently need a greater resolution in wave-length, and the addition of a calcite plate to overcome this drawback is under consideration.

Spectroheliograms in $H\alpha$ have been received from Kodaikanal for dates down to 1949 September 30.

The general magnetic field of the Sun is being measured from 70 spectrograms obtained during the summer, using the McClean solar spectrograph in its original grating form, with polarization optics and a very fine quartz Lummer plate, kindly loaned by the Royal Society through the cooperation of Professor S. Tolansky. A resolving power near to the theoretical limit, i. e. about 650,000, has been reached. Measurement is well advanced and it is hoped that the results will give the magnetic field at the Sun's poles to a few gauss. Earlier work on the same problem is also being continued, using spectrograms obtained at Potsdam, in cooperation with Dr H. Müller of Zürich.

Spectrographic apparatus has been constructed, using a 931-A electron multiplier, to seek for a displaced K line in the solar spectrum, such as might be formed by matter thrown off the Sun during a flare. The chief difficulty has been found to lie in variability of the sky transmission, but a change of spectrum intensity of 0·5 per cent can now be detected fairly certainly. Suitable flares are now awaited.

Work on the absorption bands of the solar spectrum near wave-length $4\,\mu$ has been continued, although analysis of the results is not yet complete. An investigation has been commenced of the effect of pressure on the absorption bands of nitrous oxide, both when pure and when diluted with air. Construction has started of a new infra-red spectrograph, intended for use with lead sulphide and similar cells.

Stellar Photometry.—Photoelectric measurements of magnitude have been made on 101 nights with the pulse-counting apparatus attached to the 15-inch Huggins refractor. Measures are made with Wratten 5 and 39 filters alternately, and these give results fairly near the international photovisual and photographic scales respectively. It is possible to measure to 10^m without refrigeration of the cell. Variable sky transmission appears to be responsible for the greater part of the errors of measurement. One intercomparison *aba* of nearby stars *a* and *b* gives a magnitude difference with a mean error about $0^m{\cdot}03$, while with widely separated stars the error is about 50 per cent greater. An investigation has been made into the non-linearity of the apparatus due to the finite resolving time of the counters, and an improved amplifier and counter unit, intended to improve the counting performance, is now ready for installation on the telescope. A new type of pulse-counting photometer is also under construction.

The chief application of this apparatus has been to check the photographic programme of magnitude determinations in the $+15°$ Selected Areas, which was described in last year's report. The photography for this has been finished and the measurement of the 81 pairs of plates is now rather more than half

complete. Results so far suggest that the most important error lies in the zero of each plate, again due chiefly to irregularity of the sky, and this is being corrected by numerous photoelectric intercomparisons of each Area with the Pole. Some progress has also been made with photoelectric programmes on the magnitude of Uranus and on the constancy of radiation of G type dwarfs.

Infra-red photometry with a lead sulphide cell has been continued with the 3-foot reflector. The apparatus is at present sufficiently sensitive only for red stars to 5^m (visual), or correspondingly brighter blue stars, and a good deal of further development work is still needed. A theoretical discussion of the ultimate sensitivity of radiation detectors has been made, chiefly with infra-red work in mind.

Other Investigations.—Dr Steavenson has continued his observations of old novae, the satellites of Uranus and a number of comets.

Objective prism spectrograms of ζ Aurigae obtained at the Arcetri and Vatican Observatories have been measured and some new ultra-violet lines appearing shortly before total eclipse have been discussed.

Optics.—A number of theoretical papers on Schmidt telescopes and allied optical systems have been communicated to the Society. A fifth-order aberration function for the classical Schmidt camera has been derived. Other problems which have been investigated are: the "balancing" of the monochromatic aberrations of a Schmidt telescope over the whole field, the aberrations of the classical Schmidt when used with a field-flattening lens, the chromatic aberrations of the classical Schmidt, the monochromatic and chromatic aberrations of monocentric Schmidt-Cassegrain systems. Work in progress, or in course of publication, deals with the diffraction theory of telescope star images, the phase-contrast test and the designing of fast Schmidt cameras. A 12–15-inch two-plate Schmidt-Cassegrain system is under construction. A 6–9-inch Schmidt camera, the property of the Society, has been mounted on the stub end of the Sheepshanks telescope, for experimental photography in the infra-red.

University Observatory, Glasgow

(*Director, Professor W. M. Smart*)

In October Dr H. Strassl, of Bonn Observatory, and Dr L. Randič of Zagreb Observatory, Jugoslavia, joined the Observatory as research associates for a year.

Dr Strassl was engaged in investigations on the kinematics and dynamics of the stellar system, and he also continued his work on nomographic methods in astronomy and astrophysics.

Dr Randič's main investigation was concerned with a fundamental coordinate system, independent of observations of the Sun, and its effect on the measurement of time.

Mr P. A. Sweet was engaged in researches on the meridian-plane circulation in stars and the general effect of fluid motion on the dipole moments of magnetic fields. A paper on "The Sun's General Magnetic Field" was published during the year (*M.N.*, **109**, 507, 1949) and a second paper on "The Effect of Turbulence on a Magnetic Field" was completed at the end of the year.

The Director continued his investigations in celestial mechanics.

Imperial College Observatory, South Kensington, London

(*Director, Assistant-Professor R. W. B. Pearse*)

As in previous years, the refractor and the transit instrument have been used mainly for the instruction of students.

Research on problems concerned with the analysis of atomic and molecular spectra has been continued in the spectroscopy laboratory. The work of revising and bringing up to date the compilation of data on molecular spectra by Dr Pearse and Dr Gaydon has been completed and the new edition will be published shortly. Dr M. W. Feast continued his investigation of the spectra of O_2 and O_2^+ and also studied the behaviour of other gases in a special source devised for the excitation of O_2. The distribution of intensity in the band systems of O_2 and O_2^+ was investigated theoretically by Miss M. Pillow. Dr M. Afaf obtained several new band systems for the molecule *ZrO* and discussed the possibility of their appearance in stellar spectra. The vacuum ultra-violet absorption spectra of a number of metals vaporized in a carbon-tube furnace have been photographed by Mr W. R. S. Garton, who has thus been able to identify several new terms above the first ionization potential. Transition probabilities for a number of atomic lines have been measured by Mr G. Stephenson, using a magneto-rotation method.

University of London Observatory, Mill Hill, and University College Observatory

(*Director, Mr C. C. L. Gregory, Wilson Observer*)

The Radcliffe Telescope.—This instrument was used on 155 nights, during which observations made before and after midnight were 97 and 84 respectively. The total number of plates was 906, almost all of which were for parallax; four positions of the asteroid 51 Nemausa were obtained and transmitted to Mr Ole Möller at Copenhagen Observatory. A few plates were obtained for the measurement of double stars.

Other Instruments.—The Wilson 24-inch reflecting telescope and 4-prism spectrograph were used on 16 nights. 17 spectra of the brighter Be stars were obtained. The other instruments were used mainly for teaching. Astronomy courses are being taken by eight students during the current session.

Considerable progress has been made with figuring and polishing the various parts of the mirror meridian instrument, and the electric furnace has been installed but none of the parts have yet been adhesed.

Expedition to Haute Provence Observatory.—Through the kindness of the Director, M. Dufay, the Assistant Director, Dr E. M. Burbidge, worked on 21 nights and obtained 157 spectra of Be stars for spectrophotometric measurement. She was assisted by her husband, Mr G. R. Burbidge, B.Sc., who has also given considerable assistance with the parallax programme.

Publications.—The second number of *University of London Typescript Circular*, containing a list of stars for the new parallax programme now in progress, was completed in December. A list of the first 20 parallaxes which have been obtained has been published in *Monthly Notices*.

Visitors.—The number of visitors was 398, of whom a large number were from various schools and colleges. The Fry 8-inch equatorial was used for the visitors.

University Observatory, Oxford

(*Director, Professor H. H. Plaskett*)

Solar Work.—The solar telescope and spectroscope were in continuous use throughout the good observing season from March until the end of November. Measurement of the profile of the *Kr* line, λ 4319·6, has shown that the large prismatic spectroscope in its diaphragmed form gives a markedly asymmetrical slit-pattern with a practical resolving power at this wave-length of 93,000. A brief description of the instrument and its performance will shortly be communicated to the Society.

A light-tight and readily de-mountable assembly has been designed and constructed for the application of Treanor's method of circular channels (*M.N.*, **109**, 389). This was used by Dr Adam for a determination of the interferometric wave-lengths of solar lines in the regions $\lambda\lambda$ 5100 and 6100 by a comparison with the simultaneously photographed fringe system of the red *Cd* line. Preliminary measures and reduction of these spectra make it probable, in accordance with Treanor's prediction, that the wave-lengths of laboratory lines can be found to an accuracy of 0·0004 A. and of solar lines to 0·001 A. Mr Treanor has completed his preliminary work on the determination of line profiles by his new method, and the results will be given in his D.Phil. thesis.

Spectra for a re-determination of the Evershed effect in sunspots were obtained during the period of normally good seeing in the autumn. During this same period a new set of plates for the determination of the velocity in solar granulation was obtained, using an improved technique. The plates for the Evershed effect will be measured and discussed by the recently appointed Departmental Demonstrator, Mr T. D. Kinman.

Comets.—Dr Merton completed his work on a new method of computing the perturbations of cometary orbits (*M.N.*, **109**, 421). He has continued his photographic observations of comets, and has made some preliminary experiments on the adaptation of the visual microphotometer (on loan from the Royal Greenwich Observatory) to the determination of integrated photographic magnitudes of comets and nebulae.

University Observatory, St. Andrews

(*Director, Dr E. Finlay-Freundlich*)

Staff, Research.—Mr W. L. Wilcock and, later in the year, Mr A. H. Jarrett, both from Manchester, joined the Observatory with D.S.I.R. grants to begin with experiments to improve interferometric methods of spectral analysis of solar and stellar light. A coating-plant for coating interferometer plates has been constructed and has been put into operation.

Dr Jaroslav Cisař, F.R.A.S., from Prague, joined the Observatory temporarily to take part in the work with the 19-inch Schmidt-Cassegrain telescope. He

will reside in Dundee in charge of the new telescope which is to be erected in the Mills Observatory, Balgay Hill, early in 1950 January.

The construction of the 19-inch Schmidt-Cassegrain camera was completed. The 18-point floating system to support the primary mirror was finished, likewise the mounting of the secondary Cassegrain mirror, which is kept at a fixed distance from the primary for a certain range of temperature changes by a special compensating device.

The whole camera, including the Schmidt plate, was assembled and extensive optical tests were performed.

Norman Lockyer Observatory of the University College of the South West

(Director, Mr D. L. Edwards)

The main programme of relative gradients and colour-temperatures of B- and A-type stars has continued, although observing conditions have been seldom favourable for photometric work. A new technique of photographing spectra for gradient measures is being tested, which should effect a substantial economy of observing-time. Photography of Be-type spectra on nights unsuited to photometry has been carried on as formerly.

In addition, an experimental photoelectric polarization photometer has been completed and used to study the radiation from the twilight sky in a narrow spectral band centred on 5893 A.

Dunsink Observatory

(Director, Professor H. A. Brück)

The reconstruction of the Observatory, as far as repair and conversion of buildings and instruments are concerned, has been completed during the past year. A " solar tower " has been erected on top of the Meridian Room in the form of a steel platform on which a 16-inch coelostat has been mounted. A vertical Cassegrain solar telescope has been set up inside the Meridian Room, and preliminary tests have been made of the performance of the instrument.

Work is progressing on the mounting of the projected 7-metre concave grating spectrograph which is to be used in conjunction with the solar telescope. An aluminizing plant for mirrors of up to 24 inches in diameter has been set up in close cooperation with the Physics Department of University College, Dublin, under the supervision of Dr T. E. Nevin.

The photoelectric photometer which had been constructed for use with the 12-inch refractor has been re-designed and is now working satisfactorily. Results of some interest have been obtained concerning the atmospheric extinction at Dunsink.

A 16-millimetre film camera has been converted into a Fabry photometer for photographic photometry, and a tube sensitometer has been constructed in connection with this instrument.

Work by the Perkin-Elmer Corporation on the " Armagh-Dunsink-Harvard Telescope " has been going on without interruption, and the instrument is expected to be shipped to South Africa early in 1950.

A paper on the infra-red *Ca* triplet and certain members of the Paschen series and their intensities in stellar spectra of various type has been sent to the press and will form the first number of a new series of *Contributions from the Dunsink Observatory*.

Dominion Observatory, Ottawa

(Director, Dr C. S. Beals)

Stellar Physics.—Experimental colour temperature observations of B-type stars with the 8-inch doublet were continued during the summer with a view to testing the usefulness of this low-dispersion equipment for gradient work.

An investigation of the P Cygni stars involving the collection of data from all known objects of this type and a discussion of their physical characteristics has been brought near completion. A detailed study of the star H.D. 190073 based on Victoria spectrograms was also completed during the year.

A start has been made on the design of new equipment for research in solar physics, the most important being a spectrograph designed for both photoelectric and photographic recording.

A theoretical investigation of the transfer of radiation through a stellar atmosphere has been undertaken with particular reference to the physical origin of P Cygni-type line profiles.

The programme of meteor observation was continued in cooperation with the National Research Council. Observations were carried out on the nights of the annual showers:—Lyrids, Eta Aquarids, Delta Aquarids, Perseids, Leonids and Geminids; and on other nights selected at the dark of the Moon. Over 2300 meteors were plotted visually. Three spectrographs and ten direct cameras were used for meteor photography and a total of 1600 exposures was made, resulting in more than 50 meteor photographs. Concurrently with this programme, the National Research Council operated radio equipment on the 30 megacycle band at four stations and both radar echoes and Doppler whistles were photographically recorded. Very complete visual, photographic and radio records were secured for a Perseid fireball on 1949 August 12–13 and a detailed study of this object is being made. A summary of information available from 104 meteor spectra, photographed at various places in the world, was compiled. The orbit of a daytime meteor, completely observed by radar, was published in collaboration with the National Research Council.

Positional Astronomy.—Meridian circle observations, taken during the years 1911–1923, were published and distributed. Observations on the Backlund-Hough stars, Sun, Venus and Mercury, taken 1923–1935, are being prepared for publication.

Four cameras for photographing the declination circle division marks were completed, installed and are being tested. A measuring engine for reading the films is being constructed.

A new observing programme, comprising the zenith stars for the zenith tubes at Greenwich, Richmond, U.S.A., and Ottawa, along with the FK3 reference stars is being prepared.

The Time Service is placing more reliance on crystal clocks and electronic ancillary equipment, including phase and frequency changers. Foreign time signals have been monitored and time has been broadcast continuously over

station CHU on 3330 kc./s., 7335 kc./s. and 14,670 kc./s. and once daily on the CBC network.

Plans for a photographic zenith tube have been completed. The object glass (10 inches aperture and 14 feet focal length) and the tube sections, along with the complete mechanism for reversing the rotor, will be completed early in 1950.

Seismology.—Operation was continued of the seismograph stations at Ottawa, Halifax, Seven Falls, Shawinigan Falls, Saskatoon and Victoria. Plans were initiated for considerable improvement of the Halifax station, and for the installation of a station at Resolute Bay, N.W.T. A test station, to simulate Arctic conditions as nearly as possible, was set up in the Observatory grounds for operation during the winter of 1949–50.

Considerable attention has been given to the seismicity of Western Canada. A paper on the British Columbia earthquake of 1946 June 23 has been prepared for publication; seismograms from the principal stations of the world have been accumulated for the Queen Charlotte earthquake of 1949 August 21; some attention has been given to the Seattle earthquake of 1949 April 23 as it relates to the Canadian earthquake problem; the minor seismicity of British Columbia, as shown by the new short-period Benioff seismograph at Victoria, has been studied.

The study of crustal structure in the vicinity of Kirkland Lake, Ontario, using rockbursts as a source of energy, has been continued. Stations have now been occupied out to a distance of about 180 km., although some gaps remain to be filled. Tentative travel-time curves for near earthquakes in Eastern Canada have been prepared, based partly on the foregoing studies and partly on earthquake data. An intensive study has been made of an earthquake near Montreal on 1948 May 7 and of one near Alexandria, Ontario, on 1949 October 16.

Terrestrial Magnetism.—The extension of magnetic observations to the Canadian Arctic was continued, mainly with the aid of aeroplane transportation. 28 stations were occupied, of which 25 were in the region between latitudes 60° and 78°·8 north and longitudes 60° and 120° west.

An isogonic map of Canada was constructed for the epoch 1948 July. This map is being issued in two sheets, one sheet covering all areas south of 75° and the other from 60° north to the geographic pole. Extensive revisions based on similar data were made on many detailed map-sheets and marine charts.

The magnetic observatories at Agincourt, Ontario, Meanook, Alberta, and Baker Lake and Resolute Bay, Northwest Territories, continued to operate in a normal manner.

Satisfactory progress was made in the design and construction of an airborne universal magnetometer of the electrical type and it is expected that test flights will be made during the summer of 1950.

Gravity.—360 gravimeter and magnetic stations were established with the aid of aerial transportation and a North American gravimeter in an area of approximately 150,000 square miles, covering most of the northern part of Ontario north of latitude 46°, with the exception of the low-lying areas within 150 miles of Hudson and James Bays. 700 gravimeter stations were established in Southern Saskatchewan and Manitoba with an automobile using the Mott Smith gravimeter belonging to the Observatory.

Observations were taken with a North American gravimeter (subsequently employed in the aerial work) at 15-minute intervals over a period of two weeks

from May 9 to May 23 in connection with the tidal gravity programme sponsored by the Shell Oil Company of Houston, Texas. Some 500 observations were subsequently made with this instrument and a vertical magnetometer over the MacDonald and Eldona ore deposits in the vicinity of Noranda, Quebec, for the purpose of testing the applicability and limitations of the methods in locating such deposits.

Two papers have been published, one by R. Meldrum Stewart, former Dominion Astronomer, on Gravity in the Interior of the Earth, and another by Mr Innes on the results of the gravity and magnetic observations over the East Sullivan Mine at Val d'Or, Quebec.

David Dunlap Observatory, University of Toronto

(Director, Professor F. S. Hogg)

Radial Velocities.—During the past year the general programme of velocity observations in Yale zone +25° to +30° has been continued. It is expected that results for about 250 of the 850 stars in the list will be included in the forthcoming Mount Wilson general catalogue. Professor Heard is completing the velocity determinations for a number of Be stars for the catalogue.

Orbits of seven new spectroscopic binaries have been published by Professor Heard, Miss Northcott and some students. Mr Tanner's analysis of spurious periods, and redeterminations of several binary orbits with previously published related or erroneous periods, have been published.

Photometry.—Dr Helen Sawyer Hogg has continued her studies of variable stars in globular clusters, publishing data on Messier 28 in the *Astronomical Journal*, **54**, 193, 1949. Mr R. L. Baglow has used the photo-multiplier photometer on the 19-inch on eclipsing binaries. The results of a photographic search for short-period variations in white dwarfs are summarized in the *Astronomical Journal*, **54**, 189, 1949 by W. R. Hossack and F. S. Hogg.

Miscellaneous.—Professor R. E. Williamson, with Mr G. F. D. Duff and Mr B. Oke, has continued investigations of stellar interiors. With Professor Seeger, of the United States Navy-Cornell University microwave project, Professor Williamson has completed work on the galactic plane (in press). The work of Mr D. K. Norris, on the collection and analysis of atmospheric dust for possible meteoritic components, has been extended into the Arctic. Positive results include the confirmation of the high degree of terrestrial contamination in even isolated southern regions, and evidence of nickel in some samples (*Astronomical Journal*, **54**, 192, 1949).

Since the last report *D.D.O. Publications*, **1**, Nos. 21–23, and *Communications* Nos. 18–22 have been distributed.

Union Observatory, Johannesburg

(Union Astronomer, Dr W. H. van den Bos)

Some glass disks for large reflectors are being cast at present, and it is hoped to take advantage of this fact in order to acquire a disk for a 74-inch reflector.

With the 26½-inch refractor, 952 micrometer measures of double stars were obtained and the interferometer was used on ten nights. Finsen has constructed a new interferometer.

Plates taken with the Franklin-Adams telescope were

Minor planets	267	plates
Comets	82	,,
Variable stars	57	,,
Miscellaneous	52	,,
Total	458	,,

Comets 1949 a and d were discovered by Johnson.

With the 9-inch refractor, 110 occultations have been observed. Counts of sunspots were made on 332 days with a 3-inch refractor. During the year 883 visitors were admitted on 42 nights.

Two Taylor-Hobson-Cooke lenses of 3·6 inch aperture and 20 inches focal length were acquired.

The first two quartz-crystal clocks were installed and all time signals emitted from the Observatory are now controlled by a quartz clock. Synchronous motors have been substituted for the mechanical drives of the 26½-inch and Franklin-Adams telescopes.

Circular No. 107 has been printed and distributed. Two papers, containing discussions of South African earthquakes and of the Witwatersrand earth tremors, were read by Finsen at the geophysical conference held at the Witwatersrand University.

The Astronomer Royal and astronomers Henize and King from Bloemfontein visited the Observatory.

Miss S. S. Bosman retired on pension in September, after 30 years' service on the staff. Miss B. M. A. Bee was appointed Librarian in April and resigned in October. Mr G. W. Webster was appointed Assistant Physicist in December.

Radcliffe Observatory, Pretoria

(*Director, Dr H. Knox-Shaw, Radcliffe Observer*)

The 74-inch reflector has been in regular use throughout the year, the final adjustments to the mirror having been made towards the end of 1948. Neither of the convex mirrors nor the Cassegrain spectrograph has yet been received, and the telescope can therefore be used only at the Newtonian focus. The additional equipment acquired during the year consists of (*a*) a low-dispersion spectrograph weighing only a few pounds, for use at the Newtonian focus, constructed jointly by Messrs Cox, Hargreaves and Thomson and Mr Overhill, and embodying two prisms lent by the Cambridge Observatory and an *f*/1 Schmidt camera. It shows the spectrum from 3720 to 5900 A. on a film 8 mm. in diameter; (*b*) a Schraffierkassette made in the workshops of the Cape Observatory and adapted for use on the 74-inch reflector; and (*c*) two tube sensitometers constructed by Dr Evans and Mr Cousins respectively for use in conjunction with the Schraffierkassette. The 74-inch mirror was successfully re-silvered in July, the original coat having been in use ever since 1948 April.

The Newtonian spectrograph was devoted by Dr Thackeray largely to a programme of radial velocities of southern globular clusters. He also employed it on the spectra of emission rims and other bright areas in diffuse nebulae; this work was combined with direct photography through various filters, and

the results have been communicated to the Society. In addition, a number of interesting stellar spectrograms have been procured, notably of Proxima Centauri (dMe); of RR Telescopii, which changed from absorption to emission in the course of about a month, while the star faded slightly from its bright maximum; and of the three long-period variables in 47 Tucanae (gMe). The results of this work have also been communicated to the Society.

Dr Thackeray has also taken over 40 photographs of the Sculptor system (mostly one-hour exposures reaching to about magnitude 20·5) with a view to studying the variable stars in it. In addition to the ten published by Baade and Hubble, more than 150 variables have been discovered, and it is clear that the list is far from complete. The great majority are of short period and blue in colour, relative to other stars in the cluster. The transparency of the System renders it favourable for a study of the period-luminosity relation, provided long-period Cepheids can be found.

The short-period variable VV Puppis (period only 100 minutes) has been studied both visually and photographically. Its amplitude as well as mean magnitude is subject to large variations, and at times it appears to be quite inactive. Yet when a maximum is observed, it fits a linear ephemeris dating back to its discovery in 1930. A paper on this work, in collaboration with Oosterhoff and Wesselink, is to appear in the *B.A.N.*

Photographs have been taken of the open cluster Kappa Crucis and measured for the positions of the central stars to compare with those made by Gould in 1882. No significant differential motions have been found, and the large shifts hitherto published must be attributed to observational errors.

The 21 listed planetary nebulae south of $-40°$ with diameters greater than $10''$ were photographed, mostly by Dr Evans, for the determination at a later date of their proper motions, and several of them were given varied exposures for the study of their internal structure. Dr Evans also followed up the paper which he communicated to the Society at the end of last year on NGC 5128 with a photometric study in blue and red light of the curious planetary I.C. 4406.

During October and November Mr A. W. J. Cousins of the Cape Observatory exposed 78 plates with the Schraffierkassette on five of the nine Harvard E regions as an extension to fainter magnitudes of the Cape photometric programme. It is hoped that this work may be continued in the future.

In all, 140 photographs were made with the Newtonian spectrograph and 371 other plates taken of nebulae, clusters, variable stars, standard fields, etc., on 171 nights.

Nizamiah Observatory, Hyderabad

(Director, Dr Akbar Ali)

Astrographic Equatorial.—31 plates were taken with the Astro Camera attached to the Astrographic Equatorial. The recently published measures of stars in the Hyderabad Astrographic Catalogues are being compared with the Potsdam measures for deriving the proper motions of stars in zones $+36°$ to $+39°$. 6452 stars have been compared in eight common regions during the year. It is proposed to publish the results after comparing the remaining 20 regions. The reductions of the Eros plates are nearing completion. Survey

of the double stars in zone $+37°$ has been completed and the work of examining and reducing double stars in zone $+38°$ has been taken up.

Preliminary investigations have been undertaken in connection with the Recommendation 3 of the Carte-du-Ciel Commission of the International Astronomical Union (1948), to determine whether a new calculation of plate constants in Hyderabad zones will be justified by the precision of the star measures. It is proposed to carry out these investigations with regard particularly to Hyderabad Astrographic zones $+36°$ to $+39°$ in which old and revised plate constants are available. It may be mentioned here that in the case of the published plate constants of Hyderabad zones $-17°$ to $-23°$, the difference of epochs of meridian places of the reference stars and photographic plates amounts to nearly 40 years on an average.

Grubb Equatorial.—The total number of occultations of stars by the Moon observed during the year was 30, all of which have been reduced, and the results are as usual being communicated for publication in the *Monthly Notices*. The programme of the measurements of double stars has been continued as before.

Spectroheliscope.—The routine observations of the Sun on 59 days were carried out.

Publications.—The following papers were sent for publication during the year :—

1. " Occultations of stars by the Moon observed at the Nizamiah Observatory during 1948."
2. " Stars with large proper motions in the Hyderabad Astrographic zones $+36°$ to $+39°$, IV."

Instruments.—The 8-inch photovisual object glass of the Astrographic telescope has become very much tarnished after a continuous service of nearly 40 years. Photographic observations with this telescope have therefore been stopped entirely and arrangements have been made to send the object glass to England for necessary polishing and refiguring.

In the annual report for 1947, it was mentioned that it was proposed to acquire a multiplier tube photometer from America. It is regretfully stated now that no progress in this respect could be made as permission for importing the photometer was refused on the ground of conserving the national resources of hard currency in this country.

A Facit calculating machine (T.K. model) was purchased to facilitate the heavy computational work of the observatory.

Miscellaneous.—The meteorological and seismological work of the observatory has been continued as usual.

The Director attended the meeting of the Standing Advisory Board of the Government of India for Astronomy at Kodaikanal in 1949 April.

Solar Physics Observatory, Kodaikanal

(*Director, Dr A. K. Das*)

General.—A Standing Advisory Board for Astronomy and Astrophysics was constituted by the Government of India and the first meeting of the board was held at Kodaikanal Observatory in April, when matters relating to the development of astronomy and astrophysics in India, with particular reference to the expansion of the Kodaikanal Observatory, were discussed. A report embodying the proposals was submitted to the Government.

In connection with a proposal to establish a high-altitude observatory in the Himalayas, a survey party of scientists visited certain locations for selection of a suitable site.

In pursuance of a scheme sponsored by the International Astronomical Union, daily broadcasts of coded messages (URSIGRAMMES) relating to solar activity were commenced from 1949 May 1 from the All-India Meteorological Broadcasting Centre, New Delhi, according to the following schedule :—

Call sign	Power of station	Frequencies (Kilocycles)	Time of broadcast
VVD3	3·5 kW.	5205, 7580 13,100, 17,650	14.00 and 20.00 hrs. U.T.

A practice of issuing forecasts of expected ionospheric and magnetic disturbances to the press as well as to certain scientific institutions was commenced during the year.

Professor O. E. H. Rydbeck, Director, Chalmers Geophysical Observatory, Sweden, visited the Observatory in December.

Exchange of spectroheliograms and photoheliograms with foreign observatories was continued as in previous years. 220 K-flocculus photographs for the first nine months of 1949 were supplied to the Solar Physics Observatory, Cambridge, and one photoheliogram (1948 July 24) to the Royal Greenwich Observatory. 87 $H\alpha$ flocculus and 86 calcium prominence plates relating to the period 1948 July to 1949 June were received from the Mount Wilson Observatory and 58 $H\alpha$ flocculus and 73 calcium flocculus plates for the same period were obtained from the Meudon Observatory, France.

Routine Solar Observations.—Weather conditions during the year were slightly more favourable than in 1948. The average definition of the Sun's image before 11 a.m. (I.S.T.) estimated on a scale in which 1 is the worst and 5 the best was 2·9 compared to 2·8 of the previous year. On 74 days the definition was 2 or less while on 29 days it was 4 or more. Observations of the sky and seeing conditions during day and night were continued. Observations with the photoheliograph, the prominence spectroscope, the spectrohelioscope and the spectroheliographs were carried out as usual. In addition, systematic afternoon observations on all days of the week with the spectrohelioscope and the spectroheliographs were started during the year. Direct photographs of the Sun on a scale of 8 inches to the Sun's diameter were obtained on 316 days as against 305 in 1948. Disk spectroheliograms in the $H\alpha$ and the K lines were obtained on 299 and 287 days respectively and K-prominence plates on 278 days. Quarterly statements of chromospheric eruptions were sent to Dr L. d'Azambuja of Meudon Observatory and Mr H. W. Newton of the Royal Greenwich Observatory.

Sunspots.—The number of new sunspot groups observed during the different months of the year, their distribution in the two hemispheres and the mean daily numbers are given in the following table :—

		Jan.	Feb.	Mar.	Apr.	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Total
No. of new	North	12	18	18	14	23	16	10	13	12	18	18	22	194
												Equator		1
	South	20	13	16	18	11	14	15	11	12	12	10	11	163
groups	Total	32	31	34	32	34	30	25	24	24	30	28	33	358
Mean daily No.		6·9	8·3	8·7	7·9	6·4	5·9	6·4	5·5	7·7	6·5	8·3	8·1	7·3

The total number of new spot groups as well as the mean daily number shows very little change when compared with 1948. There were no spot-free days during the year. The approximate mean latitude of the sunspot groups for the whole year was 13° as against 14° in the previous year.

Magnetic Observations.—Continuous magnetograph records were obtained of horizontal force, vertical force and declination. Absolute observations of dip were made on five days in the week and those of declination and horizontal force, once a week.

Four " Severe " and eleven " Moderate " magnetic storms were recorded during the year. The storm commencing on May 12 at $12^h\ 08^m$ I.S.T. was the severest recorded at Kodaikanal during the year. The storm was of the sudden commencement type with an initial impulse of $90\,\gamma$ in H and $19\,\gamma$ in V. The trace extended very much below the base line and a considerable portion of the record was lost. Synchronously with the storm, complete fadeout of short-wave radio reception was reported. The spot group responsible for this storm crossed the central meridian on May 11 at $17^h\ 00^m$ I.S.T. and continued to be active during succeeding days; but no eruption was noticed.

Research Work and Publications.—The following notes were published during the year :—

1. The brilliant solar flare of 1949 January 23 and the great magnetic storm of January 24–26 (*The Observatory*).
2. Line-broadening in solar flares (*Nature*).
3. Existe-t-il une corrélation entre les protubérances à disparition brusque et les perturbations géomagnétiques ? (*L'Astronomie*).
4. Geomagnetic equator (*Current Science*).
5. Solar activity and associated geomagnetic and radio disturbances during May–June 1949 (*Indian Journal of Meteorology and Geophysics*).
6. Lightning discharge at Kodaikanal Observatory (*Indian Journal of Meteorology and Geophysics*).
7. The comet of November 1948 (*Science and Culture*).

The following papers, which will appear in the Bulletins of this Observatory, were made ready for the press :—

1. Some observations on the H and K lines in the solar spectrum.
2. Relation between the base and the height of prominences.

Commonwealth Observatory, Mount Stromlo

(*Director, R. v. d. R. Woolley, Commonwealth Astronomer*)

Solar Work.—The daily routine of sunspot sketching has been maintained. Registration of 200 Mc./sec. solar radiation has been continued and compared with spectrohelioscope and ionospheric observations.

Time Service.—Transit observations have been made regularly, and rhythmic time signals have been broadcast regularly from H.M. Naval Wireless Station, Belconnen.

Astronomical Observations.—Variable star observations have been continued with an electron multiplier attached to the Oddie 9-inch refractor. The light curve of S Antliae has been secured, and the magnetic variable star H.D. 125248 has been found to be a variable with a range of $0^m{\cdot}06$ and a period of $9^d{\cdot}3$. The programme of monochromatic magnitude determinations with a slitless

spectrograph and electron multiplier on the 30-inch reflector has nearly been completed. The programme of relative gradients determined by photography with the same spectrograph and telescope has been completed and the results prepared for publication. A programme of observations of magnitude and gradient of fainter stars with a coarse grating attached to the 30-inch reflector has been commenced. Reclassification of objective prism spectra taken by Mr Rimmer on the 9-inch refractor has advanced.

Galactic radio emission (cosmic noise) of frequency 200 Mc./sec. has been observed and a survey of the southern sky completed.

48-inch Reflector.—Considerable progress has been made with the re-erection of the Melbourne 48-inch reflector. It is anticipated that Messrs Cox, Hargreaves and Thomson will deliver the new mirror by the middle of 1950. In the meantime, the concrete pier for the south end of the polar axis has been erected, and the concrete floor laid, and an extension for the polar axis has been delivered. It is expected that the polar axis will be erected early in 1950, and that the telescope will be operating at the end of that year.

74-inch Telescope.—Progress is reported by Sir Howard Grubb, Parsons and Co. in the construction of this telescope.

Workshop.—The construction of a 3-prism spectrograph has progressed so far that the instrument has actually been mounted on the 30-inch reflector and a test spectrum of α Carinae secured. The dispersion is 10 A./mm. at $H\gamma$ and excellent definition is obtained from $H\gamma$ to beyond H and K. The instrument still lacks an outer case (with thermostat) and a suitable arrangement for viewing the slit. The tests showed that the definition at the Cassegrain focus of the telescope is very imperfect, and it is proposed to construct a new convex mirror in the Observatory optical shop.

Staff.—Mr Bowe has resigned his Research Fellowship. During this year Father G. Hagemann, D.Sc., and Mr R. Brockman have joined the staff and Mr C. S. Gum has been appointed a Research Fellow. Mrs Simonow, Ph.D., has taken a temporary appointment as Librarian.

During this year the Observatory has been visited by Professor H. S. W. Massey and by Professor S. Chapman, each of whom has spent about a week on Mount Stromlo.

Riverview College Observatory, Riverview, N.S.W.

(Director, Rev. D. O'Connell, S.J.)

Photographic research on variable stars is being continued. The regions photographed regularly cover most of the southern Milky Way, from Puppis to Scutum. About 1500 plates are now available in some regions. The programme includes (1) a search for new variables brighter than $11^{m}\cdot0$ at maximum and studies of these stars; (2) studies of Cepheid variables, RV Tauri variables and other variables with double periods and eclipsing binaries. Eclipsing binaries with changing periods are being investigated. SV Centauri proved to be a particularly interesting case of this kind. It was found that a fluctuation of the period, completed in about 34 years, is superimposed on a change of period of much longer duration and larger amplitude. The short-period fluctuation can be explained as due to the varying light time across an orbit described by the binary about a third star. The elements of this orbit and the mass function of the triple system were derived.

Observations of occultations, partly reduced, are forwarded to H.M. Nautical Almanac Office.

Publications.—Publication No. 9 (Vol. 2, No. 5), containing papers on eclipsing binaries, is being printed and will be distributed shortly.

Sydney Observatory

(*Government Astronomer, Mr H. W. Wood*)

The programme of work on the Astrographic Catalogue has been continued and Volume 28 has been distributed; Volume 31 is at present in the hands of the printer. Measurement of plates and preparation of manuscript for the Catalogue have been accelerated by the appointment of two extra additional clerical assistants. The Catalogue of 1499 Intermediate Stars between 30° and 51° of South Declination for the Equinox 1925.0 has been printed and issued as *Sydney Observatory Papers, No.* 8.

The occultations predicted in the *Nautical Almanac* have been observed when possible, the results for 1948 being in the process of publication. The observations for 1949 are being reduced.

Contracts have been arranged for a new dome for the astrographic telescope, a photographic lens of 9 inches aperture and a coordinate measuring micrometer for measuring of photographic plates of side 7 inches.

The civil work, consisting of the supply of astronomical information for legal purposes, time service and the answering of general enquiries, has been carried on. The educational work of the Observatory was continued and lectures and demonstrations delivered regularly.

Perth Observatory

(*Government Astronomer, Mr H. S. Spigl*)

The West Australian Standard time service has been maintained, and distributed by Onogo, hourly, and various other time signals.

The seismograph record is complete, with the exception of periods due to power failures, and records were distributed in quarterly bulletins to 45 cooperating stations. Preliminary data were cabled to the United States Coast and Geodetic Survey through the American Consul, relating to movements within 5000 km. of Perth. A number of original seismograms were despatched to assist in certain investigations.

On the average, five nights per month were devoted to visitors, approximately 1000 being present during evening demonstrations and a lesser number in day visits. The Government Astronomer also undertakes University lecturing.

Occultations were observed and results sent to H.M. Nautical Almanac Office. Observations of sunspots by projection have been made, and other astronomical phenomena observed.

Astronomical tables of various phenomena were distributed for a number of places throughout the State, and information for legal, general enquiries and the press were furnished when required. The tide tables for Port Hedland and the North West coast, incorporating astronomical data, were completed and distributed.

Carter Observatory, Wellington, N.Z.

(*Director, Mr I. L. Thomsen*)

From February to December the Observatory was open regularly to the public on Friday evenings, when lectures and telescope demonstrations were given. Attendances totalled 1505. In January a special course of one week's duration was given to secondary school teachers. Many special sessions have been given to societies and clubs.

Observations of sunspots by projection have been made continuously and counts reported to Zürich Observatory. Commencing in November, projection drawings are now made on a 25 cm. diameter circle. Experiments with the solar camera attachment to the 9-inch telescope have shown that solar photographs with a diameter of 11·5 cm. can now be taken as required.

Forecasts of radio disturbances based on solar data have been supplied to the Post and Telegraph Department, the New Zealand Broadcasting Service and the Overseas Telecommunications Commission (Australia).

More regular observations with the spectrohelioscope have been instituted and the results forwarded to Meudon and Greenwich Observatories.

Thirteen photographs of the partial solar eclipse on October 21 were obtained through passing clouds and prints forwarded to the Division of Radiophysics, C.S.I.R., Australia, for use with their observations of solar radio noise. In addition some data were obtained by projection. It is hoped to study the data to see if useful results are possible from single photographs.

New Zealand occultation observations from 1947 January to 1948 October were partially reduced and forwarded to H.M. Nautical Almanac Office.

Photo-multiplier apparatus for use with the 9-inch telescope was constructed by an Honours student, Mr G. A. Eiby, and the preliminary trials, using a 931A tube, give hope for useful photometric work in the future.

A few observations were made of the planet Jupiter to confirm disturbances which had been reported.

Auroral observations have been collected from approximately 300 voluntary observers in New Zealand, the Tasmanian Astronomical Society, Mr Fraser Paterson at Broken Hill, Campbell Island, Macquarie Island and Heard Island. The two latter stations are operated by the Australian National Antarctic Expedition. With a view to assisting all observers and bringing uniformity into the reports, a Manual for Visual Observations of the Aurora Australis was prepared. Preliminary data on Aurora Australis displays in past years was prepared and forwarded to Dr Shrum of the University of British Columbia for his research on the incidence of both polar aurorae. Provisional lists of recent displays have been published in the Aurora Australis Circulars and the Cosmic Relations Bulletin of the Department of Scientific and Industrial Research.

The Radio Research Section of the Dominion Physical Laboratory continued to occupy the quarters provided in the Observatory.

The Observatory is indebted to gifts and encouragement received from Dr L. J. Comrie and Professor Carl Störmer. Mr H. W. Newton and Professor d'Azambuja have also taken a kindly and helpful interest in the work of the Observatory.

The Observatory of the Hampstead Scientific Society

(*Astronomical Secretary, H. Wildey*)

During the year 240 visitors were entertained at the Observatory and whilst some of these were members they were mostly the general public, who are admitted on Monday, Thursday and Saturday evenings when weather permits. The usual work was continued mainly on variable stars and Jupiter, but the low altitude and consistent bad seeing prevented much being carried out on the latter. The Sun was also observed and the spots and prominences were recorded.

A camera has recently been constructed to attach to the 6-inch Cooke refractor and the trials have proved very satisfactory.

Reports are sent to the Section directors of the British Astronomical Association.

Mr F. Addey's Observatory

Long Sutton, Somerset

Sunspot observations at Long Sutton were commenced on 1949 February 6, after the move from Buckhorn Weston, Dorset.

During 1949, 244 whole disk Sun drawings were made and 23 naked-eye spots were observed. All drawings and reports were forwarded to the British Astronomical Association.

Mr R. Barker's Observatory, Cheshunt, Hertfordshire

Conditions for seeing through 1949 were, on the whole, rather disappointing. Lunar observations partly confirmed faint, dusky, radial bands first seen on the floors of Proclus (by Thornton) and Hippalus A (by Moore) both resembling in miniature the very definite system of varying dusky bands in Aristarchus.

A series of delicate clefts north of the Straight Range, in the vicinity of Condamine and Maupertius, were mapped, but have not been fully confirmed.

A pancratic Barlow eyepiece made by Dall was used on the 12·6-inch Calver equatorial.

Mr J. Evershed's Observatory, Ewhurst, Surrey

The liquid prism spectrograph has been employed in obtaining high-dispersion spectra at the centre of the Sun's disk in the red and yellow regions, where numerous oxygen and water-vapour lines form convenient standards of reference for estimating possible changes of wave-length in the solar lines.

Measures have been made of nine iron lines and two nickel lines, with the result that every one of these solar lines shows a marked decrease of wave-length compared with the "Recommended" values of the International Astronomical Union, thus confirming previous measures published in *M.N.*, **108**, 347. The measures have been communicated to the Society.

Dr J. L. Haughton's Observatory, Fishpond, Charmouth, Dorset

The Observatory at Teddington was dismantled in 1946 and the equipment brought down to Dorset. For various reasons it was not possible to start building till about the middle of 1949, and observational work was not started

till December. It is proposed to carry on the occultation observations and photographic search for novae which were undertaken at Teddington, as well as the photography of any brighter comets that should appear.

The coordinates of the Observatory, taken from a 6-inch Ordnance Survey map are :—Latitude N. 50° 46′ 56″; Longitude W. 2° 53′ 41″; Altitude 730 ft.

The dome of the Observatory, built of magnesium alloy sheet, was very kindly made and presented by Mr R. J. Cross, Managing Director of Messrs Essex Aero Ltd., Gravesend, Kent.

Mr M. B. B. Heath's Observatory, Kingsteignton, S. Devon

Structural alterations were made, including re-covering the dome and raising the pier, whereby objects down to declination $-38°$ can now be observed with the full aperture of $10\frac{1}{4}$ in.

Mercury was observed on 30 days, five drawings being made in the favourable elongation April–May, and Venus on 18 days. Mars was observed in good conditions only once. Saturn was observed on 19 nights, estimations of satellite magnitudes and of latitudes of belts being made on 13 of them. The close conjunction of Venus and Jupiter on January 26 was well observed after sunrise.

Mr F. M. Holborn's Observatory, Streatham, London

During 1949, 2364 observations were made of 67 variable stars and five novae on 176 nights. The Sun was observed on 238 days for spot counts and naked-eye spots. All records were deposited with the British Astronomical Association.

Mr F. J. Sellers' Observatory, Muswell Hill, London

Daily telescopic and spectroscopic observations of the Sun have been made whenever weather permitted. A summary of general solar activity covering rotations nos. 1258 to 1281 is completed for publication in the *B.A.A. Journal.*

Particulars of 24 chromospheric flares, which have been observed and recorded from 1949 January 1 to December 31, have been communicated to Dr d'Azambuja for inclusion in the *I.A.U. Bulletin*, also to the Cavendish Laboratory, Cambridge and to Mr J. S. Hey.

Fog and haze, since September, have greatly interfered with efficient observation.

Dr W. H. Steavenson's Observatory, Cambridge

With the 30-inch reflector 158 observations of 18 novae were made during the year. Observations of the position-angles and relative brightness of the satellites of Uranus were made on 16 nights. In both cases the results will be communicated to the Society in due course. A synchronous electric drive for the telescope was installed in March and has greatly improved the working of the instrument.

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Mr H. Wildey's Observatory, Hampstead, London

The coordinates of the Observatory are:—Latitude N. 51° 31′ 19″·8; Longitude W. $0^h\ 09^m\ 23^s{\cdot}1$.

The $12\frac{1}{2}$-inch reflector has been mainly used for following variable stars and novae, Jupiter still being too low for observation from this site. Some time has also been given to sweeping for new comets on the best nights.

All records are sent to the British Astronomical Association.

Mr H. P. Wilkins' Observatory, Bexleyheath, Kent

During the year the Observatory was moved to 35 Fairlawn Avenue, Bexleyheath from 127 Eversley Avenue, Barnehurst. The new site offers many advantages for observation, which again has been largely confined to the Moon. The difficult limb regions have received special attention while, of the formations nearer the centre, Plato has been carefully examined. A report on the formation, with chart, has been prepared and was read at the B.A.A. meeting on November 30. As Director of the B.A.A. Lunar Section, much time has been spent in correspondence and the MS. of the 11th Report of the Section has been completed. Micrometrical measures of the mountains visible in profile on the limb, together with the positions and diameters of objects near or within the libratory regions, have been continued with the 15-inch reflector.

MINOR PLANETS

The minor planet programme was very badly disorganized at the time hostilities ceased: The Rechen Institut had moved from Berlin to Heidelberg, but about half of its staff and material remained in the Russian zone. Dr G. Stracke had died in 1943. The observatories formerly engaged in this work were not all able to return to it; and at first the quality of photographic plates was poor or a supply unobtainable. Professor Delporte, as President of Commission 20 of the I.A.U., undertook to organize international cooperation for the preparation of ephemerides. For 1946 a handwritten manuscript from Heidelberg was reproduced and distributed by the U.S. Naval Observatory. During 1947 the ephemerides which were prepared at various places were distributed in large part through the efforts of Dr Cunningham at Berkeley. Finally, 783 remaining ephemerides were computed by Dr Grosch on punched-card machines at the Watson Scientific Computation Laboratory in New York under the direction of Dr Eckert.

Since Professor Delporte had retired from his active career at Uccle, his responsibilities in this programme were gradually assumed by Professor Brouwer at Yale, the Vice-President of Commission 20. It was arranged by the I.A.U. officers that the international minor planet centre should be established at the Cincinnati Observatory under the direction of the writer. All the 1947 ephemerides were collected together and printed in one volume, resembling the former annual *Kleine Planeten.* The elements were supplied by Dr Cunningham; they are essentially the same as in the 1945 list. This volume was distributed from the Cincinnati Observatory, and copies are still available if needed for reference.

Cooperation with the Russian astronomers has not been very satisfactory, due primarily to difficulties in communication. It is known that the Institute at Leningrad has a large amount of valuable minor planet data resulting from orbit improvements and perturbation computations collected over many years. The Institute independently published a complete volume in 1947 in two parts, and so it was agreed that no I.A.U. volume would be published in 1948. The Institute prepared a complete volume for 1948, but it was not received in the western countries in due time.

The I.A.U. meeting at Zürich in 1948 resolved that henceforth the responsibility for the assignment of numbers and provisional designations and the publication of the annual volume of ephemerides shall reside with the Cincinnati Observatory; and the assignment of ephemeris computations was parcelled out amongst cooperating institutions. Some slight modifications have been recommended from the form of the former *Kleine Planeten.* The 1949 and 1950 volumes have been distributed under this plan. For 1949 all the ephemerides were computed at Heidelberg. This publication is litho-printed from copy prepared on a punched-card controlled typewriter at the U.S. Naval Observatory under the direction of Mr G. M. Clemence. A compilation of all the most reliable elements is being prepared and will be published at Heidelberg.

During 1947 the Cincinnati Observatory began the publication and distribution of mimeographed Minor Planet Circulars, similar to the former R.I.

circulars. These have now reached MPC 342. During 1945 only 36 provisional designations were assigned and in 1946 only 38. In succeeding years the number has been 100, 216 and 275. The requirements for numbering have been strengthened: observations in at least two oppositions and elements which provide a satisfactory representation are now needed. The first requirement is waived if the minor planet approaches within the orbit of Mars. Thus far only (1565) = 1948 WA has had a number assigned, but several others are awaiting completion of the second requirement.

The most significant trend in recent years is the discovery, mostly at the Lick Observatory, of a number of objects on the inner fringe of the minor planet ring. The elements of some examples are listed:

Table

Name	Incl.	Node	Peri.	*e*	*a*	*n*	Reference
1947 NH	21·41	268·00	339·60	0·1105	1·7090	0·44116	HAC 932
1947 UC	21·18	60·31	49·69	0·0377	1·8492	0·39194	MPC 211
1948 EA	18·49	348·93	264·77	0·6048	2·2627	0·28957	HAC 927
1948 OA	9·47	274·24	126·16	0·4399	1·3756	0·61089	HAC 946
1949 CA	13·38	302·65	219·55	0·1528	1·7547	0·42404	HAC 979
1949 MA	23·02	87·77	30·88	0·8269	1·0784	0·88016	MPC 286
1949 OA	39·12	130·25	140·43	0·0622	1·3912	0·60066	MPC 313

Each of the two phases of minor planet work is confronted with an enormous problem. The computational side must bridge as well as possible the interruption of ten years or more which exists in the observations of nearly 300 objects that have been placed on the "critical list". In many cases the only existing observations are in one or two oppositions and a reliable prediction at this late date is not possible. In order to increase the reliability of the predictions, the approximate Jupiter perturbations in the elements were computed at the Cincinnati Observatory for 67 objects, and these have been distributed to collaborators to be used in an orbit improvement. Some of these results have been completed. The perturbations of another list of 82 objects is now in process of being computed for the same purpose.

Once this stage of the work is reduced, it will be necessary to compute in large masses the future perturbations of most of the minor planets, so that their ephemerides will be more reliable. The great improvement in computing facilities during the last decade will make it possible to provide such accurate predictions for so large a number of minor planets which have already been well observed that no further observations will be needed for many years. Such economies will be very important, since there has not been a corresponding improvement in the observing facilities. The work of A. Patry, O. Kippes and others in establishing identities is also extremely valuable.

On the observational side there is the need to search systematically for those objects which are on the "critical list", so that they may be removed. Most successful in this respect has been the work of the Goethe Link Observatory of Indiana University, where (1192), (1322), (1362) and (1452) have been recovered. A. Patry has recovered (459) and (650), and other such objects recovered include (1235), (1392) and (1432). In this connection it is necessary to emphasize the importance of securing a confirming observation several weeks later whenever

such an uncertain object is identified. There have been too many cases of erroneous identifications based on only a single observation. These are worse than nothing, because they vitiate the future work.

There has been some discussion of the future direction of minor planet research, since statistical studies show the existence of many thousands of minor planets. Such plans must be tempered by the realization that no reliable information can be obtained unless the observations extend over a sufficiently long arc, and this the present observing facilities are not capable of achieving as the newly discovered objects become progressively fainter. At the present time both the computing and observing phases still have much to accomplish before the current state of minor planet work is put in good order; but this objective should reasonably be achieved within the next few years.

PAUL HERGET.

SOLAR ACTIVITY

Sunspots.—The immediate post-maximum years of the eleven-year sunspot cycle are often more interesting than the actual year of greatest sunspot abundance. The year 1949, with its several distinctive features, appears to mark the onset of this post-maximum phase. Yet, because of the arrested high average level of the mean daily sunspot number, the year cannot be dissociated from the general period of solar maximum.

The provisional mean daily sunspot number for 1949 is 136, exactly comparable with the final value published by Zürich of 136·3 for the year 1948 and 151·6 for the maximum year, 1947. In February, the sunspot number rose to 183, which may be compared with a high secondary peak in 1948 April of 189·7 and with the primary peak in 1947 May of 201·3—the highest monthly value for nearly a hundred years.

The largest sunspots.—About 40 groups of spots reached or exceeded an area of 500 millionths of the Sun's hemisphere. Although none of these was comparable with the giant spots of 1946–7, eight groups exceeded 1000 millionths and two exceeded 2000 millionths. The respective times of central meridian passage, latitudes and maximum areas are as follows :—

(1)	January	22·7	+23°	2400	(5)	August	23·9	+15°	1500
(2)	February	5·4	− 9°	2200	(6)	September	16·8	−13°	1600
(3)	February	27·3	+13°	1050	(7)	October	7·3	+ 9°	1700
(4)	August	1·1	−20°	1900	(8)	November	8·5	−10°	1150

The above groups were all of general bi-polar type. Nos. 4 and 5 are classified by Mount Wilson as $\beta\gamma$ and Nos. 6 and 7 are probably of the same classification as judged from their complex appearance.

Solar flares observed in monochromatic light.—Six notable flares were collectively observed in Greenwich daylight hours. The evidence for one of these (September 17) rests mainly on unmistakable geophysical effects, but a solar flare, for which no details are at present available, is reported to have been observed at the McMath-Hulbert Observatory, Michigan. The following table gives

the date, U.T. of maximum intensity, distance from the central meridian and source of information.

Notable Solar Flares in Greenwich Daylight Hours 1949

(1)	February 1	$12^h 26^m$	51° E.	Greenwich: *Observatory*, **69**, 74, 1949
(2)	February 11	$11^h 07^m$	80° W.	Cambridge, Edinburgh, Greenwich Meudon: *loc. cit.*, pp. 68, 74, 145
(3)	August 5	$08^h 09^m$	55° W.	Arcetri, Greenwich, *loc. cit.*, pp. 228, 235
(4)	September 17	$17^h 25^m$	(?13° W. or 78° E.)	Geophysical effects * McMath-Hulbert Observatory
(5)	September 18	$09^h 42^m$	69° E.	Edinburgh
(6)	November 19	$10^h 32^m$†	78° W.	Edinburgh, Greenwich

* Unusually large sudden phase anomaly in the reception of very long radio waves (*M.N.*, **109**, 28, 1949) reported by the Cavendish Laboratory, Cambridge. Geomagnetic crochet recorded at several magnetic observatories in the U.S.A. (information kindly communicated by the Director, U.S. Coast and Geodetic Survey). The time was unfavourable for crochet occurrence at Abinger.

† At this time, the abnormal total line-width of $H\alpha$ in emission was 22·9 A. as measured at Edinburgh (communicated in advance of publication).

Well-defined geomagnetic crochets were recorded at Abinger in association with Nos. 1, 2, 5 and 6. The absence of a crochet in connection with No. 3 is noteworthy. Intense bursts of solar radiation were recorded in this country on radio wave-lengths in association with Nos. 1, 3 and 6, and a large burst with No. 5. It will be seen from column 3 of the above table that with the exception of No. 4 (for which alternative positions are suggested by the presence of big sunspots) the position of each of the flares was unfavourable for a directive stream of solar corpuscules to impinge on the Earth. No great geomagnetic storm was in fact recorded within the few days after flare occurrence, but a small storm with sudden commencement onset 38 hours after the maximum of flare No. 1 may have been associated with it.

Outside Greenwich daylight hours, an intense flare on January 23 was observed at $02^h{\cdot}5$ U.T. at Kodaikanal. Forty hours later, a great magnetic storm began, together with a brilliant display of the aurora, seen particularly well in Scotland (*The Observatory*, loc. cit., pp. 77 and 119: *Journal B.A.A.*, **60**, 23, 1949). On May 10 a brilliant flare observed at the McMath-Hulbert Observatory was followed 34 hours later by a great magnetic storm. On the other hand, the evidence is not at present satisfactory for the occurrence of a very intense flare within two days before the great magnetic storm of October 13–17. A striking case of the absence of geomagnetic disturbance during very active solar conditions between September 19 and 23 must be noted.

From the frequency of major bursts of solar noise (recorded on wave-lengths of about 4 metres), very active solar periods occurred as follows:—January 30–February 7, March 11–16, March 20–26, April 9–15, May 9–12, June 4–7, June 14–17, June 26–30, July 9, July 14–15, July 30–August 7, August 22–29, September 8–18, September 24, October 1–13 and November 19–29. There is some indication, seen more clearly from the occurrence or absence of geomagnetic disturbance, that one hemisphere of the Sun was more active than the other, the active longitudes lying between 170°–0°–330°.

H. W. NEWTON.

Prominences.—The mean daily areas and numbers of calcium prominences as derived from photographs taken at Kodaikanal are given below :—

	North	South	Total
Areas (sq. minutes)	2·60	1·50	4·10
Numbers	6·39	4·41	10·80

Compared with the values for the previous year, the areas show on the whole very little change, an increase of 24 per cent in the northern hemisphere being compensated by practically the same decrease in the southern hemisphere. The numbers, on the other hand, show a decrease of 13 per cent, the decrease being solely in the southern hemisphere. The distribution of areas in latitude in the northern hemisphere shows a pronounced peak of activity in the zone 25°–30°; in the southern hemisphere the distribution is nearly uniform from the equator to latitude 45°. A comparison with the previous year's distribution indicates that the high latitude maxima have completely subsided and that the activity in the northern hemisphere between 25° and 30° has increased considerably, while the region 20°–35° S. shows little change. The distribution of numbers shows nearly uniform activity from equator to latitude ±45°.

27 metallic prominences were observed with the prominence spectroscope. 19 of these were in the northern hemisphere and 8 in the south. 18 were observed on the east limb and the rest on the west limb.

Doppler displacements of the *H*α line in prominences were observed on 68 occasions with the prominence spectroscope. In 20 cases the shifts were towards red, in 26 cases towards violet and on the rest of the occasions in both directions. Particulars of a few prominences which showed large Doppler shifts are given below :—

Date	Coordinates of prominences	Doppler displacements observed
January 4	E. limb : 25° S.	5 A. to red and 3 A. to violet
February 7	E. limb : 19° N.	7 to 8 A. to red
October 8	E. limb : 15° N.	7 A. to violet
November 8	W. limb : 18½° N.	12 A. to red

The heights of 228 prominences were measured with the prominence spectroscope in *H*α, D_3 and *H*β lines. These were compared with the heights of corresponding prominences in the K line as obtained from K prominence spectroheliograms. The mean heights were 60″·0 in K, 56″·1 in *H*α, 52″·5 in D_3 and 48″·3 in *H*β.

Particulars of Doppler displacements in prominences and *H*α dark markings observed with the spectrohelioscope are given below :—

	Displacements towards			
	Red	Violet	Both ways	Total
Prominences	13	18	26	57
*H*α dark markings ...	21	11	33	65

The mean daily area of *H*α absorption markings (without applying foreshortening correction) was 4469 millionths of the Sun's visible hemisphere, representing an increase of 28 per cent as compared with the previous year. The distribution in latitude shows maximum activity at 25°–30° N. and 20°–25° S.

A. K. DAS.

DOUBLE STARS

New Pairs.—Luyten (*Ap. J.*, **109,** 532) announces the discovery of a double star of large proper motion, Kuiper (*Ap. J.*, **108,** 542) that of a bright star. Baillaud (*Ann. Besançon*, **3,** 33) gives a list of 3016 double stars from the Algiers Astrographic Catalogue.

Measures.—Measures of double stars are given by Arend and Neven (*Ann. Obs. Roy. Belg.*, Ser. 3, **4,** No. 4), Armellini (*Contr. Mt. Mario*, Nos. 124 and 135), Baize (*J.O.*, **31,** 99, 138, 151), Jonckheere (*J.O.*, **32,** 13), Olivier and Barton (*P. Flower O.*, **7,** part 1), Van den Bos (*U.O.C.*, **5,** 259), Wood (*Sydney O. Papers*, No. 6) and Woolley, Gottlieb and Simonow (*Mt. Stromlo Mem.*, No. 9).

***Orbits*:**

Double Star		P	e	a	Computer	Reference
ADS	221	104	0·533	0·38	Muller	*J.O.*, **32,** 34
,,	1598	60	0·35	0·64	Muller	*J.O.*, **32,** 34
,,	2402	408	0·68	3·57	Woolley	*Mt. Stromlo Mem.*, 9
,,	6871	83·7	0·63	...	Mason	*Mt. Stromlo Mem.*, 9
,,	7871	314·2	0·226	0·69	Arend	*Ann. Belg.*, **4,** 4
,,	8337	77·2	0·472	0·38	Wierzbinski	*Poznan*, **B9,** 57
,,	8539	parabola			Vidal	*A.J.*, **54,** 77
,,	8573	116·1	0·773	1·63	Arend	*Ann. Belg.*, **4,** 4
,,	8635	79·1	0·104	0·43	Arend	*Ann. Belg.*, **4,** 4
,,	8680	81·2	0·222	0·57	Arend	*Ann. Belg.*, **4,** 4
,,	8804	25·9	0·500	0·66	Haffner	*A.N.*, **276,** 145
,,	8862	51·5	0·251	1·55	Arend	*Ann. Belg.*, **4,** 4
,,	8901	42·4	0·504	0·31	Arend	*Ann. Belg.*, **4,** 4
,,	9324	I 109·1	0·686	0·72	Arend	*Ann. Belg.*, **4,** 4
,,		II 785·3	0·796	1·99	Arend	*Ann. Belg.*, **4,** 4
,,	10660	74·2	0·19	1·50	Hall	*A.J.*, **54,** 106
,,	11989	665	0·62	...	Gottlieb	*Mt. Stromlo Mem.*, 9
,,	14238	392·7	0·459	1·27	Arend	*Ann. Belg.*, **4,** 4
,,	15971	859	0·46	4·82	Giannuzzi	*Mt. Mario Contr.*, 138
,,	16539	92·1	0·057	0·32	Arend	*Ann. Belg.*, **4,** 4
,,	16850	146	0·15	...	Woolley, Mason	*Mt. Stromlo Mem.*, 9
,,	17175	26·3	0·38	0·83	Hall	*A.J.*, **54,** 102
$1^h 11^m{\cdot}6$	$-69°$	81·5	0·00	...	Woolley	*Mt. Stromlo Mem.*, 9
$14^h 45^m{\cdot}8$	$-66°$	288	0·30	...	Woolley, Mason	*Mt. Stromlo Mem.*, 9
$15^h 55^m{\cdot}4$	$-57°$	26·4	0·50	...	Woolley, Mason	*Mt. Stromlo Mem.*, 9
$15^h 59^m{\cdot}3$	$-32°$	127	0·00	0·74	Woolley	*Mt. Stromlo Mem.*, 9
$17^h 09^m{\cdot}2$	$+45°$	13·1	0·73	0·71	Van Biesbroeck	*A.J.*, **54,** 163
$23^h 45^m{\cdot}3$	$-52°$	188	0·04	1·0	Woolley	*Mt. Stromlo Mem.*, 9

Wierzbinski publishes an orbit method and a note on Rakowiecki's orbit method (*Bull. Poznan*, **B9,** 57 and 163), Ishida (*Tokyo Reprint*, No. 46) writes on the stellar problem of three bodies, with application to ζ Cancri, Belorizky (*J.O.*, **31,** 183) on Newton's law, the motion of double stars and Bertrand's problem, Strand (*A.J.*, **54,** 196) on the astrometric orbit of Procyon.

Miscellaneous.—Strand and Duke (*A.J.*, **54,** 34 and 172) give the parallax and mass ratio of 99 Herc, Hall (*A.J.*, **54,** 55, 102, 106 and 109) of τ Cygn, 85 Pegs, 26 Drac and ζ Herc, Holmberg (*Medd. Lund.*, I, No. 164) of Castor and 70 Ophi, Hall (*A.J.*, **54,** 188) writes on the photographic blending of images of astrometric binaries, Baize (*Comm. O. Santiago*, **2,** No. 6), Detre (*Veröff. München*, **3,** No. 2) and Wallenquist (*P.A.*, **57,** 9) on magnitudes of double star components, Muller (*P.A.*, **57,** 389) on the photometry and colorimetry of

close double stars and (*B.A.*, **14**, 177) on a new double image micrometer. Ali (*A.J.*, **54**, 199) gives a note on ADS 3946, Giannuzzi (*Contr. Mt. Mario*, No. 147) on ADS 12050 and Arend (*B.A.B.*, **4**, 35) a linear formula for the same object. Aitken (*Obs.*, **69**, 106) writes on the outlook for double star astronony and Jonckheere (*J.O.*, **32**, 1) gives tables for rapid computation of precessions, parallaxes, magnitudes and masses of double stars.

W. H. VAN DEN BOS.

COMETS

In contrast to the two previous years, 1949 was an average one for new discoveries of comets, but rather a heavy one as regards old ones to be followed. The aftermath of 1948 was felt chiefly by observers with the large instruments that could keep comets under observation in their faint stages: eleven such faint comets, which included the two "annual" ones, and also two brighter ones, were carried over into 1949. Two of the previously known periodic comets were recovered towards the end of the year, Reinmuth (1) and Väisälä (1). The new comets totalled five, and the orbits of three of these appear to be of short period. In all, therefore, twenty comets were observed; and of these eight or nine were still observable at the end of the year.

The Schwassmann-Wachmann (1) and Oterma periodic comets were as usual recorded at around opposition, and are not designated by annual lettering. Photographic observations by Van Biesbroeck at Yerkes and H. M. Jeffers at Lick, and visual ones by Max Beyer with the 60-cm. refractor at Bergedorf, found the Schwassmann-Wachmann comet active in the latter half of January, when it brightened four or five magnitudes. Beyer saw it about fifteenth magnitude on January 21·9, a small faint nebulous object; and 25 hours later it was $14^{m}\cdot1$, with a coma $0'\cdot7$ in diameter. It appears to have reached its brightest, $13^{m}\cdot5$, on January 26, although the coma expanded up to $1'\cdot2$ on February 1. Photographs confirmed a sharp nucleus of seventeenth magnitude, and showed a fan-shaped tail $\frac{1}{2}'$ or more towards the N. or N.E. The comet then faded to about sixteenth magnitude at the end of February. Jeffers followed it till May 1 when it was 19^{m} and nearly stellar. He recorded it again at the same brightness on November 30, and in the new year.

Beyer remarks that the outburst in January coincided with the presence of a large group of sunspots and the attendant magnetic and auroral phenomena experienced here on January 24–25. In 1946 January, it may be recalled, the comet started its great brightening of nine magnitudes some two (or three) weeks *before* the great sunspot group of February came into being on the invisible hemisphere. At the start of the comet's activity on that occasion no particular activity on the Sun was noted. Maximum brightness however coincided with the transit of the large sunspot as seen from the comet.*

Oterma's comet was followed, at seventeenth magnitude (diameter 5″), by Miss L. Oterma herself at Turku, and by Van Biesbroeck and by Jeffers, till February 18; and was first observed again in the next apparition by Miss Oterma on October 30, magnitude 16·2. Unlike Schwassmann-Wachmann (1), Oterma's comet continues to remain always at about the same brightness, around sixteenth magnitude at opposition.

* Seth B. Nicholson, *P.A.S.P.*, **59**, 30, 1947.

Three of the comets of 1947 were recorded again: Whipple's periodic comet 1947 g by Van Biesbroeck and by Jeffers in January, a faint coma of sixteenth magnitude, about 7″ in diameter; 1947 k Bester by Jeffers on February 6, a nearly stellar object of seventeenth magnitude; and 1947 l, the periodic comet Schwassmann-Wachmann (2), by Jeffers as late as June 26, when its image showed it as a faint round coma of eighteenth magnitude.

Coming now to the comets of 1948, Antonín Mrkos, with the 24-inch Zeiss reflector ($f/5\cdot5$) at the Skalnaté Pleso Observatory, with an exposure of 100 minutes, was able to obtain a last observation of his own comet, 1948 a, on 1949 January 28, when its magnitude was 17·5.

The comet 1948 d Pajdušáková-Mrkos was observed again several times during the year, a well-condensed coma fading from thirteenth to sixteenth magnitude, with a stellar nucleus (Beyer), and was recorded by Mrkos himself as late as October 25 (17^m, with a very short tail), and by Jeffers on November 18 (19^m) and again in the new year.

Wirtanen's comet 1948 h came under observation in the spring and was well placed for southern observers. On April 29·7, three days before its perihelion passage, it was seen by Albert Jones (N.Z.) as a diffuse patch about 40″ in diameter, magnitude 13·3. It reached twelfth magnitude in May and June, at which time it was near the south pole, and was still under observation at around fourteenth magnitude at the beginning of 1950 (Johnson).

The periodic comet Ashbrook-Jackson 1948 i was followed till mid-February (1949), when it was 16^m, and was then recorded once more by Jeffers, on October 28, its image being of the nineteenth magnitude, nearly stellar but with a trace of tail extending westwards.

Wirtanen's comet 1948 k was observed again three times during the summer by Jeffers, the last time being on September 24 when its image showed a round coma, 5″ in diameter, of the eighteenth magnitude.

The Eclipse Comet 1948 l was still a good telescopic object, of eighth magnitude, at the beginning of the year, and was then well observed. The coma was about 5′ in diameter, moderately condensed, with a small nucleus of twelfth magnitude, and there were still some traces of a tail. The comet faded to about thirteenth magnitude by the end of March, the coma being then about $1\frac{1}{2}'$ in diameter after, however, having first increased in size to about 10′ on February 1 (Beyer). When last photographed, by Van Biesbroeck on April 3, it was 17^m, a round fuzzy spot 10″ in diameter. A report from Cordoba mentions that spectroscopic work was done there on this comet in 1948 by Sahade—the most prominent feature was the *CN* band at about λ 3880, and *Na* in emission was also noted.

Bester's comet 1948 m, which was still between twelfth and thirteenth magnitude in January, was last recorded, on February 26 by Van Biesbroeck, as a very diffuse coma some 15″ in diameter, magnitude 16. A visual observation, however, by Beyer three days earlier, gave its magnitude as 13·0, and the diameter of the coma 1′·0.

Observations of the periodic comet 1948 n Honda-Mrkos-Pajdušáková up to January 10 were mentioned in the last report in connection with the exceptional diffuseness which developed during the previous December, and with the discrepancies in the later magnitude estimates. A further observation has

since been reported. Mrkos, giving an exposure of 46 minutes with the Zeiss reflector, on January 29, obtained a diffuse image without central condensation about 80″ in diameter. The estimated integrated magnitude was 17.

The first comet of the year, 1949 a, was not discovered till May 20·8. It was found by Ernest Leonard Johnson on plates taken near ϵ Lupi during routine work on minor planets with the 10-inch Franklin-Adams camera ($f/4 \cdot 5$) at the Union Observatory, Johannesburg. It was a small diffuse object with central condensation, but without a tail, total magnitude 13·0. It was followed till September, its brightness increasing hardly at all and, after passing behind the Sun, was under observation again in mid-December, magnitude about 12½ (Merton).

The designation 1949 b was applied to an image of the twelfth magnitude on a patrol plate, exposed at the Boyden Station on May 29, which was mistakenly taken to be of a new comet, whereas it was in fact one of comet 1948 h.

The names of three astronomers at one observatory are linked as discoverers of comet 1949 c. This unusual event came about in this way. On July 2·3 a graduate student, Vainu Bappu, working under supervision by Bart J. Bok, took a 60-minute exposure plate in Cygnus, for a special programme, with the 24–33-inch Jewett Schmidt telescope ($f/3 \cdot 5$) at the Oak Ridge Station of the Harvard College Observatory. The next day, just as they started to examine the plate, Gordon A. Newkirk, Jr., an undergraduate who chanced to pass by —it had been a hot day and he was looking for his shirt !—was invited to note the excellent quality of the plate and, on inspecting it, noticed the trail of the comet.

The comet was a diffuse object, of thirteenth magnitude, showing central condensation. It brightened only slightly, and on August 17 Beyer described it as having a round coma $2' \cdot 5$ in diameter with a condensation and stellar nucleus $13^{m} \cdot 9$, and a faint tail 5′ long towards about 111°. He noted its maximum brightness, $11^{m} \cdot 7$, on September 2. Then, after passing perihelion, it faded equally slowly, being still of the thirteenth magnitude in January of the new year (Beyer).

1949 d was E. L. Johnson's second cometary discovery of the year. He found it on a plate taken with the Franklin-Adams camera on August 25·8 in Capricornus, while following up a new minor planet (1949 OG), and then also on two earlier plates taken on August 15·8 and 20·8. It was a small diffuse object, without central condensation, magnitude 13·7. It faded slowly and was kept under observation till November 19·8 when A. W. J. Cousins, who was temporarily at the Radcliffe Observatory at Pretoria, recorded it with the 74-inch reflector there, at 16^{m}. The orbit is found to be one of short period (6·8 years), and indicates that the comet made a close approach to Jupiter in 1931–32.

1949 e was the comet discovered in Pisces by Mrs Pelagija Shajn on a routine minor planet plate taken with one of the Zeiss 120-mm. cameras of the Crimean Astrophysical Observatory at Simeis on September 18·9 (later also found on plates of August 28 and September 4); and independently by Robert D. Schaldach on a plate, also a routine minor planet one, taken with the 13-inch photographic refractor ($f/5$) at the Lowell Observatory on September 20·3. It was a diffuse object with slight central condensation and a tail about half a degree long

(Shajn). The comet was then at about its brightest, between magnitude 12 and 12½. The tail must have been very faint, for W. H. Steavenson, observing the comet visually with his 30-inch reflector at Cambridge on September 25·9, found the coma round, about 1′ in diameter and without nucleus, and without any indication of a tail. C. A. Wirtanen, later the same night, obtained a plate with the 20-inch Carnegie astrographic at Lick which, with 30 minutes exposure, failed to show the tail. During October the comet started to fade slowly but was still under observation at the end of the year at about magnitude 14½ (Shajn). The orbit of this one too is of short period.

1949 f was Reinmuth's first periodic comet whose return in 1942–43 had been missed, the prediction having been in serious error due to a mistake in the published elements for 1935 on which it had been based. The comet was recovered at the present return on November 19·9 by Antonín Mrkos with the 24-inch Zeiss reflector (*f*/5·5) at the Skalnaté Pleso Observatory. It was close to the position predicted by F. R. Cripps, its image appearing as a very small coma, centrally condensed, of the eighteenth magnitude. It was also recorded a few days later by Jeffers with the Crossley reflector at the Lick Observatory, and remained observable for a short while in the new year.

1949 g was the first comet to be discovered with the new 48-inch Schmidt telescope on Palomar Mountain. It was found on two plates, taken in red and blue light in Pegasus on November 19·1 for the National Geographic Society-Palomar Sky Survey, by Albert G. Wilson and Robert G. Harrington. L. E. Cunningham, from prints of the photographs, estimated the magnitude as 12, and stated: "All the images are strong and entirely asteroidal in appearance except for a small faint tail visible on the first two plates; there is no trace of coma. . . ." (*H.A.C.*, 1052). His preliminary calculations of the elements of the orbit indicate that it was probably of short period, and the comet close to the Earth (0·16 A.U.) at discovery. Unfortunately there was a month's delay in reducing the initial observations and, as no more have been reported since November 25, a reliable determination of the elements cannot be made, and the comet must be considered lost.

Table of the Elements

Comet		*T* (U.T.)	*q*	*e*
1948 k	Wirtanen	1947 Sept. 3·9266	3·266529	1·0
1947 i	P/Encke	1947 Nov. 26·3268	0·341019	0·846248
1948 j	Johnson	1948 Apr. 9·0230	4·709302	1·0
1948 i	P/Ashbr.-Jackson	1948 Oct. 4·7479	2·310914	0·395524
1948 l	Eclipse Comet	1948 Oct. 27·4288	0·135383	0·999956
1948 f	P/Neujmin (1)	1948 Dec. 15·9472	1·547299	0·774147
1949 d	P/Johnson	1949 Sept. 16·2495	2·24778	0·376936
1949 g	Wilson-Harrington	1949 Oct. 13·166	1·0276	0·4122
1949 c	Bappu-Bok-Newk.	1949 Oct. 26·4297	2·058879	1·0
1949 h	P/Väisälä (1)	1949 Nov. 10·457*p*	1·752053	0·635182
1949 e	P/Shajn-Schaldach	1949 Dec. 7·6849	2·302071	0·412843
1949 a	Johnson	1950 Jan. 19·4413	2·551668	1·0
1949 f	P/Reinmuth (1)	1950 July 23·744*p*	2·037299	0·476943

1949 h was Väisälä's first periodic comet at its first return since discovery (1939 IV). It was recovered by Antonín Mrkos with the 24-inch reflector at the Skalnaté Pleso Observatory on December 19·2, very close to the position predicted by Miss L. Oterma. The images on the two plates obtained recorded it as a diffuse coma, about 10″ in diameter and showing some slight condensation, the total brightness being 17^m.

The unsuccessful searches for Gale's periodic comet must be put on record. The following observatories have reported making attempts to recover this comet at its return this year: Bosque Alegre (Cordoba), Boyden Station of Harvard College, Goethe Link, Lick, Lowell, Union (Johannesburg) and Yerkes. The ranges from the predicted, of perihelion date (T) and brightness, covered by these searches, were about seven days (before and after predicted) for one magnitude fainter, three and a half days for two magnitudes fainter, and barely one day for about three magnitudes fainter than predicted. It will be noted that the fainter magnitudes were inadequately covered, since it is not unlikely that the predicted date of perihelion was more than one day in error and the comet more than two magnitudes fainter than expected. The predicted magnitudes were based on the 1938 observations, and there is evidence that the comet's absolute brightness then was two magnitudes fainter than in 1927; so it may well have faded another two or three magnitudes by 1949. E. L. Johnson, on re-examining the Johannesburg plates, found that the sharp nucleus shown in 1927 was absent in 1938 and it was then also larger (and presumably therefore more diffuse), showing central condensation on only one plate. The failure to find the comet in 1949 was thus very probably due to its being a fainter object than anticipated and to the searches being too limited.

The table of the elements of cometary orbits is arranged as in the previous reports: the comets are listed in order of perihelion date; the symbol P/ indicates a periodic comet, and *p* after the perihelion date that the elements were predicted ones. The perihelion date, deduced from observations, when not given in a set of elements in the table, will be found in the notes appended.

of Cometary Orbits

Period (years)	ω	Ω	i	Equinox	Computer	Ref.	Comet
	°	°	°				
...	73·5230	121·3967	155·0734	1948·0	Cunningham	1	1948 k
3·30	185·1852	334·7485	12·3515	1950·0	Foxell	2	1947 i
...	191·8475	139·6919	53·2440	1948·0	Cunningham	3	1948 j
7·47	348·8941	2·3580	12·5127	1950·0	Cunningham	4	1948 i
...	107·2613	210·3290	23·1227	1950·0	Hirst	5	1948 l
17·93	346·6945	347·1485	15·0019	1948·0	Cunningham	6	1948 f
6·85	206·0551	118·1787	13·8732	1949·0	Hirst	7	1949 d
2·3?	91·95	278·64	2·20	1949·0	Cunningham	8	1949 g
...	89·4887	309·0238	105·7731	1950·0	Schmitt	9	1949 c
10·52	44·3322	135·4647	11·2804	1950·0	Oterma	10	1949 h
7·76	217·1994	168·0454	6·6501	1949·0	White	11	1949 e
...	40·1576	221·6222	131·3493	1949·0	Cunningham	12	1949 a
7·69	12·8760	123·5994	8·3896	1950·0	Cripps	13	1949 f

REFERENCES AND NOTES TO TABLE OF ELEMENTS

1948 k Wirtanen. (1) L. E. Cunningham, *H.A.C.*, No. 1002. Represents 14 observations covering 57^d.

1947 i P/Encke. (2) J. T. Foxell, MS. From a differential correction of Merton's elements (*M.N.*, **108**, 128, 1948; ref. No. 15), using four observations covering 92^d and assuming a corrected from prediction, $a = 2{\cdot}217971$.

1948 j Johnson. (3) L. E. Cunningham, *H.A.C.*, No 1015. Represents 17 observations covering 87^d.

1948 i P/Ashbrook-Jackson. (4) L. E. Cunningham, *H.A.C.*, No. 1031. Represents 21 observations covering 152^d, with approximate perturbations (Venus to Saturn) included. Osc. epoch 1948 September 6·0.

1948 l Eclipse Comet. (5) W. P. Hirst, MS. Provisional, semi-definitive, from 102 observations of nine observatories, covering 146^d, with perturbations included. Osc. epoch 1948 November 25·0. He has undertaken the definitive determination.

1948 f P/Neujmin (1). (6) L. E. Cunningham, *H.A.C.*, No. 1037. From four observations covering 211^d, with $a = 6{\cdot}850910$ based on Van Biesbroeck's prediction. The residuals are still unsatisfactory.

1949 d P/Johnson. (7) W. P. Hirst, *U.A.I.C.*, No. 1246. From Johnson's 14 observations covering 62^d. Represents an observation 34^d later to $3''$.

1949 g Wilson-Harrington. (8) L. E. Cunningham, *H.A.C.*, No. 1052. From the only three reported observations, covering 6^d. The elements are very uncertain, but probably the orbit is of short period.

1949 c Bappu-Bok-Newkirk. (9) A. Schmitt, *U.A.I.C.*, No. 1225. From observations covering 24^d.

1949 h P/Väisälä (1). (10) Miss L. Oterma, *Handbook B.A.A.*, 1949, 52. Prediction based on her 1939 elements. Osc. epoch 1949 February 13·0. Observation indicates T 1949 November 11·30.

1949 e P/Shajn-Schaldach. (11) Miss Amelia White, *H.A.C.*, No. 1035. From five observations covering 8^d. Elements still very uncertain.

1949 a Johnson. (12) L. E. Cunningham, *H.A.C.*, No. 1063. Represents ten observations covering 96^d.

1949 f P/Reinmuth (1). (13) F. R. Cripps, *Handbook B.A.A.*, 1949, 54. Prediction based on his elements for 1935. Osc. epoch 1950 July 18·0. Observations indicate T 1950 July 22·66.

ADDITIONAL NOTES

1932 I Houghton-Ensor. A. Przybylski: "Orbite définitive de la comète 1932 b (Houghton-Ensor)"; *Acta Astronomica*, Sér. **a**, **5**, 1, 1949. He gives the details of his definitive investigation, completed a few minutes before leaving for the field of battle in 1939. The resultant elements were included in our report in *M.N.*, **107**, 108, 1947; ref. No. 17, to which should now be added the epoch of osculation 1932 April 13·0.

P/Encke. J. Bouška and Z. Švestka: "On the variation of the Coma-Diameter of Encke's Comet"; *Bulletin of the Astronomical Institutes of Czechoslovakia*, **1**, (8), 123, 1949. They find a correlation between solar activity and coma diameter, but not absolute brightness. A correlation between diameter and solar relative-numbers, they recall, was found by P. Ahnert in the case of comet 1943 I Whipple-Fedke; ref. *Z. f. Ap.*, **22**, 286, 1943.

Brightness of Comets. Studies in the brightness of some recent comets, by J. Bouška and by V. Vanýsek, will be found in *Bulletin of the Astronomical Institutes of Czechoslovakia*, **1**, Nos. 5 and 6, 1949. They include comets 1947 k Bester, 1947 n, 1946 c P/Giacobini-Zinner, 1948 g Honda-Bernasconi, and 1946 a Timmers.

G. MERTON.

ADDRESS

Delivered by the President, Professor W. M. Smart, on presenting the Gold Medal of the Society to Professor Joel Stebbins

The Gold Medal of the Society has been awarded by the Council to Professor Joel Stebbins for his development of physical methods in astronomical photometry and for the results obtained by the use of these methods. Professor Stebbins has found it impossible to be with us today to receive the Medal in person; we are glad, however, to welcome Dr C. S. Piggott, Scientific Attaché to the American Embassy, who will act as his proxy on this occasion.

It is now my privilege to describe in some detail the paths traversed by our Medallist from the time, over forty years ago, when the Moon was kind enough (although with some initial hesitation) to furnish him with his first successful photometric observation with a selenium cell, right up almost to the present day when we find him engaged in the exciting occupation of trying to locate the central core of the Galaxy. During these intervening years he has been in the forefront of photometric progress and now the present equipment, which he and his colleagues have been operating, is almost as far removed in complexity from the early selenium photometer as the 200-inch Hale telescope is from the instruments in use at the beginning of the last century. With one or two exceptions, so far as I can discover, Professor Stebbins' observational investigations have been entirely photometric in character. Further, he would appear to be one of the very few astronomers since the time of Sir William Herschel—if not the only one—who has turned his instruments on nearly every known species of celestial object; he has pointed his photometer at the Sun, the Moon, planets, satellites, a comet, all sorts of stars variable and invariable, novae, star clusters, galactic and extragalactic nebulae and, last but not least in importance, he has investigated the obscuring matter of the Galaxy. The only objects of a distinctive kind absent from this catalogue would appear to be meteors and planetary nebulae; with these exceptions he has thus taken the entire heavens as the realm of exploration and we shall see how he has achieved successes which would have exceeded his most sanguine expectations three or four decades ago.

It is perhaps significant that our Medallist's first published paper (with Comstock) was a photometric study of the magnitude changes of Nova Persei (1901) when he was a young graduate student at Washburn Observatory. Later, in 1901, we find him at Lick Observatory engaged in a long spectroscopic investigation on Mira Ceti—his only considerable departure from photometry. Soon he was appointed Director of Urbana Observatory in the University of Illinois, where he remained until his departure in 1922 for a similar position in the Washburn Observatory at Madison. His official retirement came nearly two years ago, but his migration to Mt. Hamilton as a Research Associate is an indication that his absorbing interest in photometrical investigations is not by any means diminished.

His principal telescope at Urbana was a 12-inch refractor with an objective by Brashear. It is characteristic of Professor Stebbins that he is content with only the best performance of which his instruments, whatever they may be, are capable. At Urbana he soon discovered that the Brashear objective had not

given satisfaction for several years and he took immediate steps to have the imperfections remedied. He had now, for its size, a first-rate instrument for his planned programme of photometrical measures of heavenly bodies. His Madison instrument was a 15-inch refractor, and as a Research Associate of Mt. Wilson of several years' standing he has enjoyed the facilities provided by the two large telescopes there for several weeks each year.

The necessity for the accurate photometry of the stars was first realized not much more than seventy years ago. At Oxford Pritchard developed the wedge-method of correlating the magnitude of a star with the minimum thickness of a neutral-tinted glass wedge required to produce extinction of the starlight. On the continent the Zöllner polarizing photometer was in active employment—with this instrument the light of a star and the light of a standard source were equalized and from the known properties of the optical system the magnitudes of the stars on the usual scale could be deduced. At Harvard the meridian-photometer was devised by E. C. Pickering, in which the light of the star could be compared by means of a polarizing apparatus with the light of Polaris. In subsequent years the photographic plate has been extensively used in determining photographic and photovisual stellar magnitudes. On a conservative estimate, the limit of accuracy in all these methods is represented by a probable error for a single observation of perhaps a little less than $0^{m}\cdot05$ numerically—and, it may be added, the visual photometers are effective for only the brighter stars.

Early at Urbana our Medallist turned his attention to the possibility of utilizing for precise photometry what we now call, in general, the photoelectric effect. But while he was experimenting with selenium cells his 12-inch telescope was not otherwise inactive, and the first substantial contribution was the measurement, by means of a polarizing photometer, of the magnitudes of the components of 107 double stars brighter than the ninth magnitude. Even in this early programme he was on the look-out for variations in brightness and additional measures were made on suspected variables. It is significant to note that, with a probable error of about $\pm 0^{m}\cdot06$ for a single determination, the accuracy attained was insufficient to detect the light-changes in Polaris and δ Orionis, the variability of which was later established by non-visual methods. The visual photometer was also employed in deriving the light-curve of δ Cephei—the most accurate up to date (1908). Previously, from the radial velocity measures, Belopolsky had considered the star to be a spectroscopic binary; now, our Medallist was certain that it could *not* be an eclipsing system, and he made a plea for new radial velocity measures (the star had been neglected in this respect since Belopolsky's observations) for, as he said, "it would seem that a series of observations with a modern instrument would yield interesting and valuable results"; evidently, he sensed something of fundamental importance as regards stars of this class and we now know how abundantly his instinct has been justified.

It is convenient to give at this point some account of the instrumental developments in the application of photoelectricity to astronomy. The first indication of the phenomena associated with the photoelectric effect appears to have been reported by Hertz over seventy years ago when he noticed that light falling on a spark-gap had the effect of making the spark pass more readily than without this aid. A little later Hallwachs discovered that the charge on a negatively electrified conductor decreased when ultra-violet light was allowed to

fall on the conductor, while a positively charged conductor remained unaffected in similar circumstances. Later still, it was found that potassium and sodium, when irradiated by light, emitted negatively charged particles and, at the end of last century, Lenard showed unmistakably that these particles were electrons. It was also discovered that certain insulators and semi-conducting substances (amongst them is the element selenium) responded to the influence of incident light, for their conductivities increased and their resistances diminished. The photoelectric effect thus takes two forms; so far as the alkali metals, on exposure to light, are concerned, electrons are emitted while, as regards selenium, for example, the electrical resistance of the element diminishes. In the first case (known as the "outer effect") the absorption of a suitable quantum of the incident light-energy by an atom results in the expulsion of the outermost electron of the atom; in the second case (known as the "inner effect") the acquisition of light-quanta by atoms results, not in the emission of electrons, but in raising them into the "conduction level", thereby increasing the conductivity of the selenium and so diminishing its electrical resistance. In the first case it is sufficient to note, first, that for a given element such as potassium no expulsion of electrons occurs unless the frequency of the incident radiation exceeds a certain limiting value (the "threshold" frequency)—or, what is the same thing, unless the wave-length is less than a certain value—and, second, that for each wave-length the rate of expulsion of electrons is proportional to the intensity of the corresponding incident radiation. The relevance of the second property to photometry is obvious; to compare the brightness of two stars, so far as photoelectric wave-lengths are concerned, all we have to do, theoretically, is to count the number of electrons emitted per second from the metal when irradiated by the light of the stars in turn, and the ratio of the two numbers is then readily converted into a magnitude-difference on the particular photoelectric scale concerned. In the second case the resistance of selenium, for example, diminishes at a rate proportional to the intensity of the incident radiation and the ratio of the rates for two stars is then converted into a magnitude-difference, as in the first case.

Dr Stebbins began his experiments with selenium cells, as I have already remarked, soon after he went to Urbana. Some of the cells he made himself, but his most satisfactory one was the product of a Dutch firm, Giltay of Delft. The cell itself consisted of two wires wound close together over a small flat insulator, the spaces between the wires on one side being filled with selenium in the crystalline form. The proper sensitizing of the selenium was evidently a trade-secret jealously guarded by Giltay, but even the relatively minor idiosyncracies of a Giltay cell imposed a strain on the patience and perseverance of our Medallist. The resistance of a cell is of the order of a million ohms at normal temperatures and it increases very markedly with diminution of temperatures, the rate of increase being of the order of 20,000 ohms per degree centigrade. It is essential, then, for accurate photometry to maintain the cell at a constant temperature and this Stebbins achieved by surrounding the cell with ice.

The measurement of the change in resistance when the cell was exposed to starlight was made by means of a galvanometer, the cell itself being the fourth arm of a Wheatstone bridge circuit. A constant current was maintained through the cell, and when a steady condition had been reached, as shown by the galvanometer, after suitable bridge adjustments had been made, the cell was then

ready for the observer. One disadvantage of a selenium cell is its comparatively slow recovery from the exposure to light; the normal exposure was ten seconds, after which the cell was rested for about a minute before the next observation was undertaken; in the case of a very bright object such as the Moon, the recovery-time was as long as five minutes. The colour-sensitivities of the cells used in observations were determined from intensity-measures of strips, about 80 A. wide, of the solar spectrum formed by a small grating spectroscope, the widths chosen being generally sufficient to minimize the effects of absorption lines. Without going further into details it is sufficient to remark that the maximum sensitivity of all the cells used was in the neighbourhood of 7000 A.

But it was not long before Professor Stebbins was thinking in terms of new techniques and in 1911 his fruitful collaboration with Dr Jacob Kunz in the manufacture of photoelectric cells began. The pioneers in photoelectric photometry were Guthnick and Rosenberg in Germany but it was our Medallist who, by his perseverance and determination to utilize all technical advances for the ultimate perfection of this form of photometry, was to a great extent responsible for the almost incredible sensitivity of the present-day instruments.

For some years the best cell at Urbana was a potassium hydride quartz cell, the potassium having first been distilled in a vacuum on a silver coating on the inner surface of the cell and the hydride formed by a glow-discharge through pure hydrogen; after the remaining hydrogen had been evacuated, argon was introduced at a pressure of about a third of a millimetre of mercury for the purpose of increasing the sensitivity through ionization by collision of the expelled electrons with the gas. A potential difference of about 300 volts was applied between the inner surface of the cell (the cathode) and an insulated metallic ring (the anode) within the cell, the object being, of course, to increase the rate of expulsion of electrons. The light from the objects under observation was admitted to the cell through a clear part of the quartz surface (the window) and the photoelectric current produced was measured by means of a string electrometer up to 1927 when it was superseded by a Lindemann electrometer, described by Professor Lindemann (now Lord Cherwell) in *Monthly Notices*, **86,** 600, 1926.

In the earlier observations the equipment was able to provide accurate measures for stars of type A as faint as the seventh magnitude. By 1925 a much more sensitive potassium cell had been manufactured by Kunz—a "real prize", as our Medallist described it. By 1928 he was already thinking of the possibility of increasing the sensitivity of his photometer by amplifying the minute current—of the order of 10^{-15} amperes at the limit of detection—by means of vacuum-tubes, and experiments were carried on for four years at Washburn, where Stebbins had now the expert assistance of Dr A. E. Whitford. When our Medallist, in 1934, mounted his photometer on the 100-inch telescope at Mt. Wilson, now fortified by Whitford's thermionic amplifier, the new apparatus was capable of reaching the fifteenth magnitude; ten years later, further technical advances, culminating in what is known as the R.C.A. multiplier photo-cell, put stars of the eighteenth magnitude within the compass of the instrument.

In comparing the brightness of the two stars A and B, the usual procedure was to take, for A, three readings by a stop-watch, of the drift of the electrometer needle (or string) over a given number of scale-divisions, then six readings for B, followed by three for A, etc., according to the scheme:—

$$A\,3,\ B\,6,\ A\,3,\ A\,3,\ B\,6,\ A\,3;$$

a simple calculation then gave the difference of magnitude between A and B for the mid-time of the series. When a variable was under observation, sometimes two comparison stars were used, with a symmetrical arrangement rather more complicated than that just referred to. When the stars under observation were markedly dissimilar in magnitude, approximate equalization in brightness was effected by means of one of several neutral-tinted glasses absorbing from two-thirds of a magnitude to about three magnitudes.

Potassium cells have their maximum sensitivity in the region of 4600 A.; the colour equation of the first quartz potassium cell was found to be $0^{m}\cdot70$, this figure representing the difference of photoelectric magnitudes between a star of type Ao and a star of type Ko of the *same* visual magnitude.

In precise photometry it is necessary to take into account the absorption of the atmosphere which, for a given observation, is represented—in magnitudes—by $f \sec z$; here z is the star's zenith distance and f is the absorption coefficient representing the difference of magnitude for a star at the zenith observed through the atmosphere and hypothetically observed outside. In comparing one star with another the correction to the observed difference of magnitude arising from atmospheric absorption is

$$f(\sec z_1 - \sec z_2);$$

accordingly, in the observations of a variable star, for example, a comparison star is selected as near the variable as possible and also of the same spectral type, for f is also a function of wave-length. The value of the coefficient f depends on the " seeing " at the time of observation and was estimated by Professor Stebbins and his colleagues according to an empirical scale. At Washburn the minimum value of f on the photoelectric scale appeared to be $0^{m}\cdot35$; if f exceeded $0^{m}\cdot6$ the night was deemed to be unsuitable for photoelectric observations.

About 1930 our Medallist began an extensive study of the colour indices of stars, in which he employed two colour filters, one with maximum transmission in the violet at 4260 A. and the other in the blue at 4770 A. In his most recent series of observations with the Mt. Wilson reflectors half a dozen filters were used in conjunction with a caesium oxide cell, ranging from the ultra-violet at 3300 A. to the infra-red at 12,500 A.

We come now to describe some of our Medallist's investigations, beginning with the era of the selenium cell; in many of these he had the assistance, at Urbana, of Dr C. M. Huffer, and at Madison, of Dr A. E. Whitford, who has just succeeded him as Director of the Washburn Observatory. I have remarked earlier that the Moon provided the first successful observation; later, in a series of observations he compared the light of the Moon with a standard candle placed at a suitable distance from the cell and so derived a light-curve according to phase for the mean distances of the Moon and Sun; the light of full-moon was found to be 0·22 candle-metres, in good agreement with visual observations made elsewhere; further, the light of full moon was found to be nine times the light of half moon, an apparent anomaly explicable in terms of the irregularities of the lunar surface. A partial eclipse of the Moon provided him with another opportunity of testing the capabilities of the equipment and, plotting galvanometer deflections against time, he found that the instant of minimum light occurred within 0·6 minute of the time predicted by the ephemeris. Observations of Halley's Comet in 1910 demonstrated the advantage of a cell in integrating the light from an extended object.

The most noteworthy investigation with the selenium cell was the precise determination of the light-curve of Algol. The periodicity of the light-changes had been established by Goodricke in 1782, but it was more than a century later that Vogel's radial velocity measures corroborated Goodricke's surmise that the variation in light could be interpreted in terms of the eclipse of a bright star *A* by a relatively dark component *B*. But, despite all efforts, the eclipse of *B* by *A* had eluded detection by visual methods. This problem of observing the secondary minimum appeared to have been in our Medallist's thoughts at the beginning of his experiments with the selenium cell. With α Persei and δ Persei as comparison-stars he established the light-curve shown in Fig. 1, which is based on a large number of normal places in the sense: mag. (Algol)—mag. (α Persei); for the first time the secondary minimum (with a depth of $0^m{\cdot}06$) had been observed, and it is now easy to understand why the less accurate visual methods had proved unsuccessful. The performance of the apparatus at this time is indicated by the smallness of the probable errors assigned to a normal place, namely, $\pm 0^m{\cdot}023$ at or near secondary minimum.

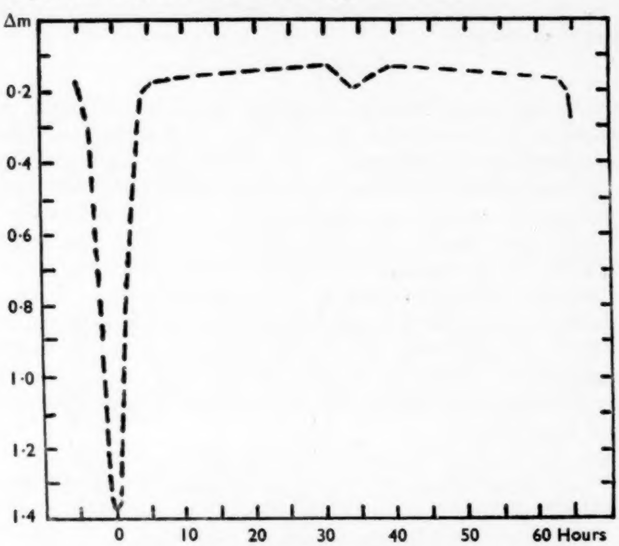

Fig. 1.—*Light-curve of Algol.*

But the discovery of the secondary minimum was accompanied by another, namely, that of the continuous variation on either side of the secondary minimum, a feature that suggested to Dr Stebbins, first, that the fainter component *B* keeps one hemisphere towards the brighter component *A*—in other words that the period of rotation of *B* about an axis is equal to its orbital period with respect to *A*, this latter period being associated with the light-curve—and, second, that the hemisphere exposed to the radiation from *A* is brighter than the other hemisphere. This was the first occasion on which what is known as the "reflection effect" was observed.

On the assumption that the illumination over each hemisphere of *B* was uniform, all possible information was extracted from the light-curve by an ingenious

analysis, and with the best available value of the parallax, 0″·07 (nearly double the best modern value), and with the information derived from the radial velocity measures of Schlesinger and Curtiss an attempt was made to deduce the physical characteristics of the binary system; as one essential piece of information was still lacking, the procedure involved the introduction of an assumption. Discarding, for good reasons, the results of a first assumption that the mean densities of *A* and *B* are equal, our Medallist assumed that the masses of *A* and *B* are in the ratio of 2 : 1. The problem was now soluble and one of the principal results was the evaluation of the mass of *A* as 0·37 times the Sun's mass, with *B*'s mass of course half this. We now know that these results are considerably wide of the general run of stellar masses but it is to be remembered that, forty years ago, little was known of this physical characteristic of the stars.

Returning to the "reflection effect" we note that Professor Stebbins was convinced that the greater brightness of the hemisphere of *B* which was irradiated by *A* was not purely a reflection effect of the kind associated with the reflection of sunlight from the Moon's surface but resulted from the *heating* of the exposed hemisphere of the darker star by the intense radiation from *A*. In this connection he remarked that the problem of the interaction of the radiation between the components of a close binary of the Algol type had not previously been considered, no doubt because of the insufficient degree of accuracy hitherto attainable in visual photometry. It was a decade and a half later that Eddington and Milne first dealt with the theory of radiative equilibrium of the outer layers of a star subjected to external radiation. In particular Eddington showed that a star in a steady state has a heat-albedo of unity and that the external radiation maintains the surface layers of the irradiated star at a higher temperature than they would otherwise have.

Ten years later Stebbins returned to the study of Algol, employing the much more accurate photoelectric photometer now in use. In the intervening years a new complication had been added, arising from the spectroscopic evidence for a third component of the system with an orbital period, with respect to the original binary system, of 1·9 years. However, the general features of the binary as determined by the selenium cell were confirmed, with the addition of an effect arising from the slightly ellipsoidal shape of the components. It may be added, as an index of the increased accuracy now attainable, that the probable error of a normal place on the light-curve at or near principal minimum was $\pm 0^{m}\!\cdot\!007$ as compared with $\pm 0^{m}\!\cdot\!023$ for the selenium cell. Further, from the colour sensitivities of the selenium and potassium cells the spectral type of the darker component *B* was estimated to be about G0.

The year 1924 saw the theoretical establishment of Eddington's mass-luminosity relationship and its success with stars of known mass and luminosity. Algol, however, was a conspicuous exception when the masses, based on Stebbins' assumption to which I have referred earlier, were used in conjunction with its absolute magnitude derived from more recent parallax measures. Two years later McLaughlin and Rossiter at Ann Arbor succeeded in finding the additional factor necessary for the unique solution of the binary problem; this factor followed from the measurement of the differential radial velocity at or near the limbs of the bright component *A* on either side of the principal minimum when only a comparatively small crescent of *A* was left uncovered by *B*. It was then deduced that the mass of *A* was five times the solar mass and the ratio of the

masses of the two components was 5 : 1. The brighter component now satisfied the requirements of the mass-luminosity relationship.

As an appendix to this account of Algol, I may mention briefly the most recent discussion of the system by O. J. Eggen, a young colleague of our Medallist at Washburn, based on a long series of observed minima of the star. In addition to the third star (component *C*) to which I have referred there seems to be fairly good evidence from the changes in the period of light-variation in favour of the existence of a fourth component *D* with an orbital period of 188·4 years; the masses assigned to *A*, *B*, *C* and *D* are 5·0, 1·0, 1·2 and 3·8 in terms of Sun's mass. From the six-colour photometric observations made by Stebbins in 1942 at Mt. Wilson, Eggen infers that the component *B* is a sub-giant of class F8 (very close to our Medallist's original estimate) and of absolute magnitude +2·5. Because of its comparatively large mass Eggen suggests that the new component *D* has the characteristics of a white dwarf. When Sir William Herschel was apprised of Goodricke's surmise as to the binary character of Algol he turned his telescope upon the star but could not see it otherwise than " as distinctly single " : our illustrious first President would no doubt have been considerably astonished if he could have learned of the much more remarkable character which subsequent investigations attribute to it.

At the total solar eclipses of 1918, 1925 and 1937 Dr Stebbins measured the integrated light of the corona with his photoelectric apparatus; at the last of these eclipses (in Peru) the entire weight of the equipment was but 40 lb. and was taken abroad by our Medallist as hand-luggage. A brief summary of the results of these observations includes the following conclusions: first, there is little evidence of any noticeable variation of the total light of the corona in the sunspot period; second, the brightness of the corona, photoelectrically, is just about one-half that of the full moon; third, there is no evidence of Rayleigh scattering, from which it is further inferred that the continuous and Fraunhofer spectrum can be produced by electrons or large dust particles but *not* by atoms, molecules and particles of wave-length dimensions; and, lastly, over a considerable range of wave-lengths the intensity distributions for the Sun and corona are the same—a consideration of great importance for any general theory of the corona.

The successful performance of the selenium cell led to a new venture—the systematic attempt to discover light-variability in spectroscopic binaries. In a paper in 1911 Stebbins discussed the possibilities and probabilities of such discoveries, and it is noteworthy that the first two binaries tested—β Aurigae and δ Orionis—proved to be eclipsing systems. The inclinations of the orbital plane of spectroscopic binaries are, of course, inclined at all sorts of angles to the plane perpendicular to the line of sight and it can be readily seen that, for an eclipse to be possible, the inclination must be within a few degrees of 90° and that the linear separation between the components must be relatively small; with normal values of the stellar masses the latter condition implies short periods and relatively large ranges in the observed radial velocities; alternatively, when one spectrum alone is recorded, the magnitude of the mass-function can be used as a criterion. Since the approximate times, t_1 and t_2, of the hypothetical principal and secondary minima could be deduced from the spectroscopic data, the test for light-variation consisted of observing the star concerned at t_1, or at t_2, and at some other time roughly halfway between these two times. The search was indeed fruitful and when the photoelectric cell replaced the selenium

cell further discoveries followed, the range of light-variation at principal minimum being sometimes only a few hundredths of a magnitude. The discovery that δ Orionis was an eclipsing system settled one important point. In the first decade of the present century it was argued in some quarters that the radial velocity measures of some of the alleged spectroscopic binaries, such as δ Orionis, could be interpreted in terms of single rotating bodies, the suggestion being that the observed displacements of the spectral lines are due to anomalous dispersion. Dr Stebbins was quick to point out that, although such considerations might apply to variables of the δ Cephei type, the discovery of eclipses in δ Orionis established beyond doubt the binary character of the star—and of others as well.

In the course of the work on testing spectroscopic binaries for light-variation several new variables were accidently discovered; the latter had originally been selected as comparison stars for the binaries under review. Among them may be noted the giant stars ζ Andromedae which our Medallist hoped might prove to be an eclipsing system of later type, none of which were known in those days; however, the analysis of the light-curve disappointed this expectation, for the star proved to be a non-eclipsing binary with ellipsoidal components. Another ellipsoidal variable discovered in Urbana in 1920 was b Persei with a total range in light-variation of only $0^{m}{\cdot}06$, the probable error of a normal place in the light-curve being a little less than $\pm 0^{m}{\cdot}003$.

Descriptions, in some greater detail, of one or two interesting eclipsing systems during this successful programme are worthy of presentation on this occasion.

(i) δ Librae (spectral type, Ao)—a well-known eclipsing binary. The light-curve was analysed by Russell's method and the dimensions of the system deduced from the spectroscopic measures of radial velocity of the brighter component. Using the Mt. Wilson estimate of absolute magnitude and Eddington's mass-luminosity relationship, with bolometric and temperature corrections applied, the mass of the brighter component was found to be 2·7 times the Sun's mass; the mass-function then gave the mass of the darker component to be 1·2 times the solar mass. Other physical characteristics of the system (including the "reflection-effect") were also found.

(ii) IH Cassiopeiae (B3)—an eclipsing variable discovered at Urbana in 1918, with ranges of $0^{m}{\cdot}132$ and $0^{m}{\cdot}032$ at principal and secondary minima. Both minima are unmistakably flat and it is evident that one eclipse is annular and the other total. As our Medallist remarked, this system is peculiarly favourable for investigating the darkening (if any) at the limb of a B type star from the annular eclipse of the larger and brighter component by the smaller star (the ratio of the radii is nearly 3:1). The flatness of the minima would appear to rule out any appreciable darkening effect. To test the matter further, the magnitude effect was calculated on the assumption that the *B* star had a coefficient of darkening equal to that found for the Sun by Abbot, according to whom, it will be remembered, the intensity of light at the Sun's limb is just one-quarter of the intensity at the centre of the solar disk; the calculation showed that the measurable effect must be of the order of $0^{m}{\cdot}025$ and since the precision of the observations firmly rules out the possibility of such an effect being overlooked, it is concluded that any darkening in the case of a B type star must be inappreciable. Our Medallist goes on to say that, as the darkening effect is conspicuous for the

Sun, it seems plausible from this investigation and from other considerations to expect a progressive darkening in spectral types varying from approximately zero in the B stars to extreme effects in K and M stars.

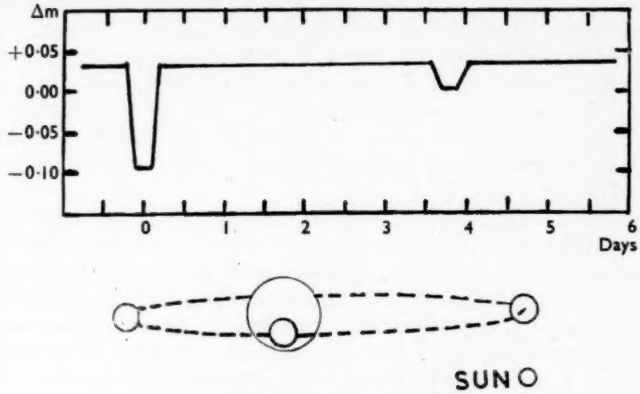

FIG. 2.—*Light-curve and system of IH Cassiopeiae.*

(iii) α Coronae Borealis (A0); the variability of this star was discovered at Urbana in 1912, the period being almost exactly 17⅓ days; only the principal minimum was observable (Fig. 3). The nature of this period necessitated observations over no fewer than six observing seasons—if one minimum is observed under satisfactory conditions, the next two minima will occur in daylight or when the evening conditions are unfavourable; since, at Urbana, only one night out of three or four on the average proved suitable for photometric observations, it then follows that a minimum could be followed satisfactorily only once in about six months on the average. From the shape of the minimum, it was inferred that here we have an annular eclipse of a brighter and larger star by a smaller and relatively dark companion; the slight departure from flatness at minimum was ascribed to darkening at the limb of the brighter star. Since the

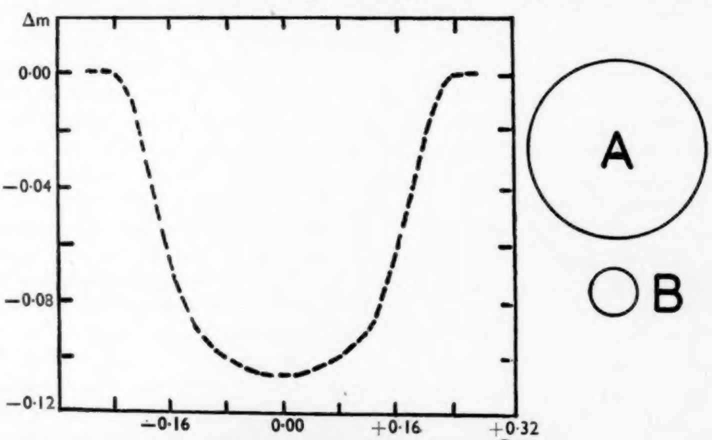

FIG. 3.—*Principal minimum (enlarged) of α Coronae Borealis, with relative sizes of components.*

star is a member of the Ursa Major cluster, its absolute magnitude is known with considerable accuracy. The masses of the two components and the dimensions of the system are deduced, using the mass-luminosity relationship, the mass-function and the information provided by the radial velocity measures. A notable feature is the high density of the dark component, found to be equal to the Earth's average density. Another unusual feature is the large orbital eccentricity of 0·39.

The high accuracy attainable by the photoelectric photometer and the possible incidence of systematic errors arising from an incomplete knowledge of the atmospheric absorption coefficient from night to night suggested a new instrumental development to Professor Stebbins, ever on the look-out for means of eliminating all sorts of errors as much as possible. I quote his own words: "So long as we observe stars *consecutively* rather than *simultaneously* we shall be at the mercy of the atmosphere and at an ordinary station this is an obstacle that cannot well be overcome. If we could arrange a double telescope so that two stars could be observed together there might be an increase in accuracy. I have experimented with this scheme in mind but it has not been possible to secure the necessary sensibility". Fortunately, this disappointment was not of much account, for soon he was to spend a part of each year at Mt. Wilson where the idiosyncracies of the terrestrial atmosphere at less favoured observing stations are reputed to be almost unknown.

In the Urbana period our Medallist made a long series of photometric observations on Nova Aquila (1918) with several colour-filters. Apart from the intrinsic value of these observations, his experiences on this occasion convinced him that with the technique employed it would be quite feasible to work out a method of determining, with considerable accuracy, the spectral type of any star.

The next big observational programme was concerned with the photometry of 190 red giant stars, brighter than $6^{m}\cdot 0$, with the possibility of light-variation ever in mind. Without specifying the rather generous criteria adopted for establishing variability, it is sufficient to state that no fewer than 51 stars were found to be variable, the light-ranges being at least $0^{m}\cdot 1$, while eleven more were put into the category of "suspected variables". This long investigation, taken in conjunction with observations of other stellar types, had two important conclusions of a general nature. First, no variability was found for giant stars of types from B to K9. Second, the degree of variability of M giants increased in passing from M0 to M6, suggesting that probably all red giants of these types are variable and that such stars form a connecting link between the constant K giants and the long-period variables of the Mira class. Perhaps it may be appropriate in this connection to refer briefly to a long series of observations of α Orionis, starting from 1908 and continuing up to 1931. The irregular fluctuations in the brightness of Betelgeuse over a few weeks are well known, but when these are smoothed out it is shown that there remains an underlying fluctuation in brightness of about half a magnitude in a period of a little less than six years, in satisfactory accordance with the period suggested by the radial velocity measures of the Astronomer Royal, when at the Cape, and also of the Lick observers.

In 1930 our Medallist embarked on a new enterprise, which has engaged his attention—although not exclusively—ever since. Up to that year the statistical study of the spatial characteristics of the Galaxy had proceeded on the assumption that, apart from the obscuring areas made familiar by Barnard's photographs of the Milky Way, there was little or no absorption of light from distant objects, an

assumption that had been earlier strengthened by Shapley's investigations on globular clusters and was little affected by Plaskett and Pearce's spectroscopic studies of the stationary H and K lines in the spectra of O and B type stars which were conclusive as to the existence of an interstellar cloud of calcium atoms. Then came Trumpler's research at Lick on open clusters—about a hundred in number and all highly concentrated towards the galactic equator—which put a new complexion on the material structure of the Galaxy. His investigation pointed unmistakably to the existence of an absorbing layer of matter disposed on either side of the median plane of the Galaxy to a depth of perhaps two or three hundred parsecs and, assuming that the layer was of uniform texture over the galactic longitudes investigated, he showed that its dimming effect could be represented by an absorbing coefficient of $0^{m}{\cdot}67$ per kiloparsec for photographic light and about half of this for visual light. A visit to the Lick Observatory in 1930 stimulated our Medallist to investigate the properties of the absorbing layer by photoelectric methods and he at once inaugurated the first of a series of observational programmes on distant objects, starting with the B stars and followed in turn by globular clusters and extragalactic nebulae.

As regards the B stars (in his first programme the number was 733) the procedure consisted in measuring the colour index of each star by means of violet and blue filters, the former with maximum transmission at 4260 A. and the latter at 4770 A. Over a hundred B stars, at least 15° from the galactic equator and brighter than $6^{m}{\cdot}0$, were used to provide *normal* colour indices with reference, of course, to the filters referred to; such stars, it was assumed, were not affected substantially by absorption. In the same way observations of a hundred giant stars of types A and M provided, for comparison and later needs, colour indices for these stars on the same scale.

Consider now the measured colour index of a B star at or near the galactic equator; in general terms this was found to be greater algebraically than the normal colour index; the star, in fact, appeared redder than a normal star. The increase in colour index is the *colour excess*, E. It is to be remarked that the reddening of several B stars had been noticed before by others, including Greaves, Davidson and Martin at Greenwich, and in such cases the degree of reddening was suspected to be correlated with the depth of the calcium cloud. By 1932 our Medallist had determined the colour excesses of the 733 stars from observations on at least two nights for each star. To allow for observational errors he adopted the following set of criteria: stars with values of E between $-0^{m}{\cdot}07$ and $+0^{m}{\cdot}05$ were regarded as normal; reddening was suspected if E lay in the range $+0^{m}{\cdot}06$ to $0^{m}{\cdot}10$; stars with E exceeding $+0^{m}{\cdot}10$ were definitely regarded as showing reddening.

The first step in the reduction was the revision of the distances of each of the B stars. Assuming that photographic absorption was twice the visual absorption (as found by Trumpler) and finding that the colour equation on the photoelectric scale was just half of that of Seares' photographic-visual scale—the colour equation, it will be remembered, is the difference of the colour indices of A0 and K0 stars of the same visual magnitude—he calculated for each star its visual magnitude m_c, corrected for absorption, from the formula

$$m_c = m_0 - 2E,$$

when m_0 is the observed visual magnitude. With the best available values of the absolute magnitudes of the B stars a simple step enabled the corrected distance of

each star to be obtained. Although the procedure for an individual star must involve some uncertainty, yet for statistical purposes this revision of distances has been of great value.

In discussing the variation of reddening with galactic longitude, we begin with longitudes in the neighbourhood of the anti-centre of the Galaxy; for no star as faint as $7^{m}\cdot5$ was the value of E found to exceed $+0^{m}\cdot30$. It would seem that the faintest B stars observed extend to the outer regions of the Galaxy in the anti-centre direction or at least to the farthest bounds of the obscuring cloud, a conclusion fortified by our Medallist's subsequent observations of still fainter stars at Mt. Wilson. It may be added that the coefficient of space-reddening in the anti-centre direction was found to be $0^{m}\cdot10$ per kiloparsec on the photoelectric colour scale. The galactic centre was out of reach at Madison, the observable part of the galactic circle nearest the centre being at longitude 350°; there the coefficient of space-reddening was found to be as high as $0^{m}\cdot67$ per kiloparsec on the photoelectric scale, more than six times that in the anti-centre direction.

About this time Hubble's counts of extragalactic nebulae, observed in different parts of the sky, became available; this investigation was instrumental in defining a zone about the galactic equator apparently avoided by the extragalactic nebulae, their absence being of course attributable to absorbing material. It was within this zone that the most reddened stars were found and outside of which reddening was relatively inconspicuous.

To compare his results, in general, with the coefficients of photographic absorption found in other investigations, the photoelectric coefficients were transformed into photographic coefficients on the basis of the considerations I have already mentioned. At the anti-centre the photographic coefficient was found to be $0^{m}\cdot40$ per kiloparsec, increasing irregularly to $2^{m}\cdot68$ at longitude 350°; Trumpler's results, averaged over the galactic equator, gave, as we have seen, a coefficient of $0^{m}\cdot67$, while a later estimate by Joy was $0^{m}\cdot85$. However, this and later investigations by our Medallist led him to the firm conclusion that the absorption of interstellar material—both as regards distance from the Sun and as regards galactic longitude—is much too irregular to be represented by anything of the nature of a mean coefficient.

I have described in some detail the methods adopted by Stebbins in his first investigation of interstellar absorption, for they set the general pattern of more elaborate researches. Within a few years he had nearly doubled the original number of B stars, many of the additional stars—of fainter magnitude—being observed with the Mt. Wilson reflectors.

To obtain some idea of the obscuring matter in the neighbourhood of the Sun, two groups of A stars—in default of B stars—one group within 30° of the galactic pole, and the other within 10° of the north celestial pole, were observed for evidence of reddening. The conclusion of this work, briefly stated, is that the Sun appears to be immersed in a fairly uniform layer about 500 parsecs thick, the photographic absorption being about 1^{m} per kiloparsec.

Not content with B stars, our Medallist began to push farther afield and his investigations, by means of two-colour photometry, of the reddening of globular clusters and, later, of the extra galactic nebulae soon followed. The colour excesses were found in the way described for the B stars and, in addition, the photoelectric magnitudes of these objects—or, in some cases, of their central regions only—were determined with reference to standard stars.

A notable result of the work on globular clusters is the close relation between colour excess and the space-absorption as shown by Baade's counts of extragalactic nebulae in the fields of globular clusters; nebulae are detected in such fields when the colour excess, E, is less than $0^{m}\cdot 19$ and are altogether absent in the photographs when E exceeds $0^{m}\cdot 20$—a remarkably sharp dividing line. The observational data for the clusters led to a revision of the individual distances of these objects, from which it was concluded that the diameter of the galactic system is about 30,000 parsecs—a considerable reduction from Shapley's original estimate. Further, the new dimensions of the Galaxy and the greatly increased dimensions of the Andromeda nebula which Stebbins had earlier deduced from photoelectric observations of its outlying regions, show that there is very little difference in the overall dimensions of the two systems.

The two-colour photometry I have described in relation to B stars, globular clusters and extragalactic nebulae is, of course, insufficient for the derivation of a relationship, if such exists, between absorption and wave-length. About a dozen years ago other investigators had suggested that selective absorption appears to vary inversely as the wave-length; this ruled out atoms and molecules as the principal scatterers of light and it was inferred that particles, mainly non-metallic, of diameter from 10^{-5} to 10^{-3} cm. could reproduce the characteristics of the absorption observed. By 1939 our Medallist had available a caesium-oxide cell sensitive between 3300 A. and 12,500 A. and in a six-colour study of three pairs of B stars (mainly by Whitford) at wave-lengths covering most of this range, one star of each pair being highly reddened and the other with negligible colour excess, this relationship appeared to be substantially confirmed; it may be explained that the object in pairing the stars as indicated was to eliminate the effects of atmospheric absorption for the different colours. A much more comprehensive investigation was later undertaken involving the observations of a large number of O and B stars, in which the atmospheric extinction factors, according to wave-length derived by Abbot, were used for the individual stars; the main result of this work was the significant deviations at different wave-lengths from the λ^{-1} relationship. Our Medallist remarks: "the deviations from this law now give the theorist further material for study" and adds that it now seems certain, since the law of reddening appears to be the same in all directions of the Milky Way, that some sort of equilibrium must have been reached and that the interstellar dust-cloud is at least a semi-permanent feature of the Galaxy.

A by-product of the six-colour photometry was the detection of a new infrared emission in the night-sky radiation at 10,440 A. A similar well-known radiation in the night sky had been explained in 1937 by Professor Chapman in terms of the recombinations of oxygen atoms formed by dissociation of molecular oxygen in daylight in the upper atmosphere. The new radiation has been interpreted by Dr Swings in terms of a somewhat more complicated process of recombination of nitrogen atoms.

The methods of six-colour photometry were next applied to the derivation of the light-curves of δ Cephei in each of the different colours. Our Medallist remarks that the combination of the 60-inch telescope and the Mt. Wilson sky made it possible to establish the six light-curves from observations on 18 nights only, with very much less effort than was formerly expended on deriving the single light-curve of a variable star. With the colour temperature of 5500 deg. for a

standard star of type G6 as basis, it was found by applying Planck's formula that at maximum the colour temperature was 6500 deg., decreasing to 4900 deg. at minimum, the corresponding spectra being those associated with super-giants of types F4 and G2 respectively. Since the star is practically on the galactic equator, the question of possible reddening arises, but it was concluded that at a distance of 170 parsecs the degree of reddening would be inappreciable.

The six light-curves of δ Cephei reveal a new feature not previously suspected, so far as I am aware; this is the progressively later occurrence of maximum (and of minimum) with increasing wave-lengths, the difference between the times of maximum for the ultra-violet and the infra-red being no less than 6½ hours approximately (Fig. 4, in which only four of the colour light-

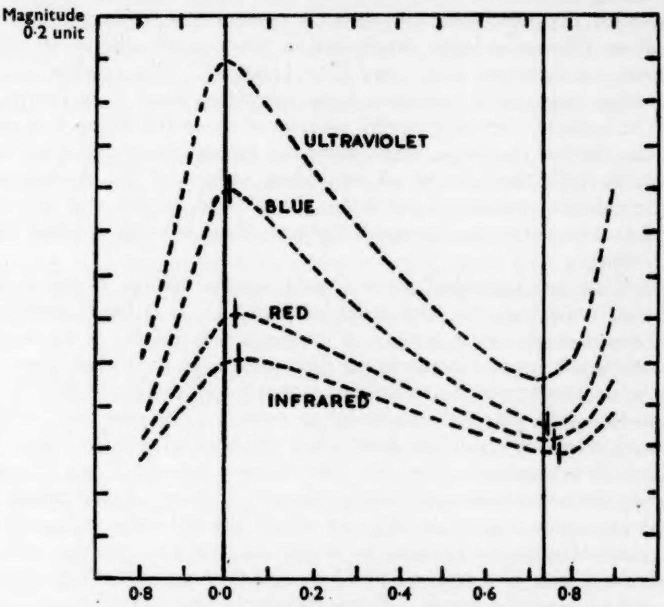

FIG. 4.—*Light-curves of δ Cephei in four colours.*

curves are shown). A possible and perhaps obvious explanation of the displacements in phase is in terms of the varying rates of transmission through space of light of different wave-lengths; however, this revolutionary suggestion is summarily dismissed. Perhaps I might interpolate that the difference of the velocities of ultra-violet and infra-red light, if the hypothesis is more seriously considered, amounts only to one part in 600,000 or, say, ½ km. per sec.—perhaps about one-quarter of the probable error of the velocity of light recently determined by my colleague Dr R. A. Houstoun employing a new technique. Our Medallist's own opinion as to the retardation of phase is that the effect arises from pulsations in the atmosphere of the star as well as in the radius. Here we have a new complication for the theoretical astrophysicist, for a complete theory of Cepheid variability, sufficiently complex already, must take into account this new phenomenon of displacement of phase with wave-length.

A similar investigation on the light-variations of Polaris shows that the amplitudes range from $0^m{\cdot}166$ at 3530 A. to $0^m{\cdot}036$ at 10,300 A.; in each colour the range is almost exactly one-ninth of the corresponding range for δ Cephei. There is some evidence for an increase in the period of light-changes—in the sense contrary to that believed to appertain to δ Cephei—but it would seem that owing to the smallness of the ranges observed this conclusion should not be pressed too strongly. For the same reason the individual light-curves could hardly be expected to reveal any progressive change (if any exists) of the phases according to the wave-length.

I shall refer, very briefly, to our Medallist's attempt in 1947 to locate the central nucleus of the Galaxy. The observations with the 60-inch at Mt. Wilson consisted in noting the galvanometer deflections for the infra-red filter (10,300 A.) at intervals, with the telescope stationary, in narrow zones several degrees in extent and at different galactic longitudes in the neighbourhood of 326°. A similar series was obtained with a red filter (7190 A.). The maxima of the infra-red readings appeared to indicate a bulge extending about 8° in longitude and 4° or 5° in latitude. From a careful analysis of space-reddening it is concluded that the light of the bulge, when corrected for absorption, adds up to a total comparable with the light of an equivalent section of the Andromeda nebula. The galactic position of the bulge, its general outline and its total light suggest, as it is cautiously expressed, that something is being detected near the galactic centre.

Our Medallist's last published paper (1948), on the colours of the extragalactic nebulae, is perhaps the most remarkable of all. It is based partly on unpublished observations, made in 1947, of the magnitudes of 175 of the nearer nebulae and of the colours of a hundred; the deduction made from these observations, which is used in the present connection, is that the elliptical nebulae form a homogeneous class with very little dispersion in colour. The paper to which I am now drawing attention is concerned with faint elliptical nebulae for which the red-shifts are well determined—18 in the Virgo Cluster, 3 in the Coma Cluster, 4 in the Corona Borealis Cluster and, finally, the very faint and distant nebula in Boötes, of photographic magnitude 18·2, for which the red-shift, expressed in terms of recessional velocity, amounts to 38,900 km. per sec. Colour indices were first obtained with blue and yellow filters and then converted into colour indices, C, on the international scale. It was then found that the values of C and of V, the red-shift velocity, are closely related by the linear formula

$$C = 0{\cdot}84 + 1{\cdot}33 .\ 10^{-5}\ V.$$

The numerical value of the second term on the right-hand side for a given distant nebula must of course include—or may even be equal to—the reddening arising from the bodily displacement of the nebular spectrum to the red. To evaluate this effect the energy-distribution for the nearly elliptical companion, M32, of the Andromeda nebula was first obtained from the six-colour photometric observations of that body; with the spectrum displaced to the red according to the value of V, the resulting degree of reddening could then be ascertained. For the Boötes nebula the reddening due to this cause amounted to $0^m{\cdot}22$, a value which was satisfactorily checked by a calculation by means of Planck's formula for a black body at 6000 deg. But for this nebula the

second term on the right of the above equation amounts to $0^m{\cdot}52$, thus leaving an unexplained excess reddening of $0^m{\cdot}30$, nearly 60 per cent of the whole.

Returning to the above formula for a moment we see that if we adopt as a tentative, and perhaps reasonable, hypothesis that increasing reddening (as given by the second term) is proportional to distance, it follows that the observations of the elliptical nebulae are in full support of a linear velocity-distance relationship by " a line of reasoning quite independent of the magnitude scales ".

Two possible explanations of the excess-reddening effect are offered. The first is in terms of selective absorption by *internebular* material with general characteristics (except as regards density) similar to those of the galactic cloud. On this hypothesis the total mass of such material is estimated to be from 10 to 100 times the total mass of the visible nebulae. A revision of nebular distances when such absorption is taken into account would, it is argued, introduce difficulties in reconciling the smooth run of nebular counts and further we should have to contemplate a relativistic universe of much smaller radius of curvature and of a much higher smoothed density than we are accustomed to at the present time.

The second explanation is in terms of a time-effect. We now see the Boötes nebula, for example, as it was two or three hundred million years ago ; the excess reddening might then be attributed to a considerable population of red giants. In this interval the original red giants of the nearby nebulae—such as M32—would, as a result of evolutionary changes, have long ceased to be effective contributors to the reddening effect. The argument would appear to suggest that from the time of their earliest existence the nebulae had sufficient material for the more or less continuous formation of red giants until roughly 200 million years ago when the process began conspicuously to decline. Perhaps this may prove to be a significant feature in the evolution of nebular systems.

Although we may not be able at present to find a really definite explanation of the observed colour excess, it is hardly necessary to emphasize that this newly discovered effect must have serious repercussions in the interpretation of nebular counts, involving revision of the distribution of energy-intensities for the nebulae and also luminosity changes depending on their distances.

In surveying our Medallist's work over the long period of nearly fifty years one cannot but be impressed by his devotion to one great department of astronomy which he in great measure has made his own, by his observational skill, his attention to detail and his critical analysis of the new and unexpected phenomena which his observations have brought to light. In the course of its long history our Society has been very sparing of its awards for photometric research, but I am sure that you will agree that the present award goes some way worthily to redress the balance. Our Medallist of 1950 has received many honours in his own country; perhaps I ought to remind you that in 1918 Professor Stebbins was elected an Associate of our Society in company with Seares and Shapley—an alliterative fraternity all connected with photometry in some form or other.

Dr Piggott, I now hand over to you the Gold Medal of our Society for transmission to Professor Stebbins; we send with it an expression of our liveliest admiration for his many notable researches. His official retirement marks, I suspect, only the beginning of a new phase of activity at the Lick Observatory and we send him our best wishes for the future.

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